December
1902

ANALYSES OF

PIG IRON

COLLECTED AND PUBLISHED BY

SEYMOUR R. CHURCH

SAN FRANCISCO

CALIFORNIA

U. S. A.

ANALYSES
of
PIG IRON

VOL. II

COLLECTED AND PUBLISHED BY

SEYMOUR R. CHURCH

SAN FRANCISCO, CAL., U. S. A.

PRICE $5.00 POSTPAID TO ANY PART OF THE UNITED STATES OR CANADA
OTHER COUNTRIES, 24 SHILLINGS

Press of H. S. Crocker Company

RESPECTFULLY DEDICATED TO

THOMAS D. WEST

CHAIRMAN, AMERICAN FOUNDRYMEN'S ASSOCIATION STANDARDIZING BUREAU

THOMAS D. WEST.

PREFACE.

THE cordial reception given to Volume No. 1 of "Analyses of Pig Iron" fully justifies the issuance of this, the second volume. So far as the writer is aware, no publications of a similar nature have ever been undertaken, and the books will therefore be found to fill a place hitherto unoccupied in the literature upon the subject.

The publisher desires it understood that the contents of this volume are in no way a repetition of Volume No. 1, but that the present volume is made up of entirely new and additional analyses, data and leading articles.

It should be borne in mind, however, that neither volume is really complete without the other, and that, taken together, they constitute as complete a compilation of analyses and characteristics of the pig irons of the world's markets as has ever been collected.

Where an analysis is given in both Volumes 1 and 2 for the same kind of iron, it is understood that the analysis appearing in this Volume takes precedence over the one previously published.

The securing of the information contained in the books has involved an amount of work and correspondence, the extent of which can hardly be appreciated by one who has never undertaken anything of the kind. The analyses published are taken direct from reports furnished by the respective furnaces, or their agents, and these reports will be kept on file for the inspection or convenience of subscribers.

The gathering of matter for Volume No. 3 is now under way, and that volume will be issued as soon as sufficient data can be collected. The writer will be pleased to receive from furnaces or their agents in any part of the world, for insertion in the forthcoming volume, analyses, cuts showing fracture of irons, photographs of plants, or any information relating to their products which has not appeared in previous volumes.

The price of each volume has been fixed at five dollars, post-paid to points in the United States and Canada, or twenty-four shillings post-paid to points elsewhere.

In conclusion, the publisher desires to express his sincere appreciation of the interest shown in the work by the many persons and firms to whom he has addressed inquiries, and to add that he is especially indebted to Messrs. Thomas D. West, F. H. Knight and Albert Ladd Colby for their valuable and timely articles which appear in this volume.

THE PUBLISHER.

Index to Names of Companies, United States of America.

Index to Brands, United States of America.

Index to Names of Companies, England.

Index to Brands, England.

Index to Names of Companies, Scotland.

Index to Brands, Scotland.

Index to Names of Companies, Wales.

Index to Brands, Wales.

Index to Other Countries.

Index to Brands, Other Countries.

Index to Illustrations.

Index—Miscellaneous.

PRODUCTION OF PIG IRON IN THE UNITED STATES.

FURNISHED BY "THE IRON AGE."

1810	53,908	1870	1,665,179
1820	20,000	1880	3,835,191
1830	165,000	1890	9,202,703
1840	286,903	1900	13,789,242
1850	563,755	1901	15,878,354
1860	821,223	1902, First 6 months	8,808,574

Production of Pig Iron in the United States, from 1898 to 1901, by States.

States.	Gross Tons of 2240 Pounds			
	1898.	1899.	1900.	1901.
Massachusetts	3,661	2,476	3,310	3,386
Connecticut	6,336	10,129	10,233	8,442
New York	228,011	264,346	292,827	283,662
New Jersey	100,681	127,598	170,262	155,746
Pennsylvania	5,537,832	6,558,878	6,365,935	7,343,259
Maryland	190,974	234,477	290,073	303,186
Virginia	283,274	365,491	490,617	448,662
North Carolina Georgia	13,762	17,835	28,984	27,333
Alabama	1,033,676	1,083,905	1,184,337	1,225,212
Texas	5,178	5,803	10,150	2,273
West Virginia	192,699	187,858	166,758	166,597
Kentucky	100,724	119,019	71,562	68,462
Tennessee	263,439	346,166	362,190	337,139
Ohio	1,986,358	2,378,212	2,470,911	3,326,425
Illinois	1,365,898	1,442,012	1,363,383	1,596,850
Michigan	147,640	134,443	163,712	170,762
Wisconsin Minnesota	172,781	203,175	184,794	207,551
Missouri Colorado	141,010	138,880	159,204	203,409
Oregon	....	....	....	
Washington	....	....	....	
Total	11,773,934	13,620,703	13,789,242	15,878,354

Production of PIG IRON in the United States, Great Britain and Germany, from 1889 to 1901, inclusive.

Years.	United States. Gross Tons.	Great Britain. Gross Tons.	Germany. Metric Tons.
1889	7,603,642	8,322,824	4,524,558
1890	9,202,703	7,904,214	4,658,450
1891	8,279,870	7,406,064	4,641,217
1892	9,157,000	6,709,255	4,937,461
1893	7,124,502	6,976,990	4,986,003
1894	6,657,388	7,427,342	5,380,038
1895	9,446,308	7,703,459	5,464,501
1896	8,623,127	8,659,681	6,372,575
1897	9,652,680	8,796,465	6,864,405
1898	11,773,934	8,609,719	7,232,988
1899	13,620,703	9,305,319	8,143,132
1900	13,789,242	8,959,691	8,520,541
1901	15,878,354	7,761,830	7,860,893

Imports of PIG IRON into the United States in the years named, including Spiegeleisen, Ferro-Manganese and Ferro-Silicon.

	Gross Tons.
1871	219,228
1875	74,939
1880	700,864
1885	146,740
1890	134,955
1891	67,179
1892	70,125
1893	54,394
1894	15,582
1895	53,232
1896	56,272
1897	19,212
1898	25,152
1899	40,393
1900	52,565
1901	62,930
1902, First 6 months	115,607

UTILITY AND MIXING OF PIG IRON.

By Mr. THOMAS D. WEST, Sharpsville, Pa.

FURNACEMEN'S RESPONSIBILITY AND THE VALUE OF CHEMICAL AND PHYSICAL TESTS.

The progress of the past few years in the acceptance of chemistry by foundrymen replacing the appearance of fracture as a guide in defining the grade of pig iron and making mixtures, is an advance that should be encouraged by blast furnacemen as well as by founders. The sooner all recognize that the appearance of pig fracture can often be deceptive and that by chemical analysis alone is it possible to insure accuracy in defining the grade of pig iron, the sooner will contention cease between makers and users of iron regarding bad or unsuitable iron.

It is not right that a foundryman should always hold a furnaceman responsible for any undesired results obtained by remelting his pig iron. There is no brand or grade of pig iron made but what is suitable for use in some class of castings. This being indisputable, why should a furnaceman be held responsible because a foundryman ran his iron into the wrong moulds. With the present opportunities of obtaining a true analysis, and a well-mixed cast of pig iron, a founder should rarely be allowed any other excuse than that he poured his iron into the wrong mould, if he does not get the grade of iron he wished in his castings. There is about as much sense in a founder expecting that a furnaceman should give him the right kind of iron for his special castings without his stipulating just the averages he wants in chemical and physical properties, as there would be for an engineer to think of erecting an iron bridge or building of whatever material he should obtain from the mills, had he asked them to send what they thought best. A founder who is so ill-informed with the opportunities available for gaining knowledge of cast-iron and making mixtures at the present day as to have to ask others to decide what he should use, is deserving of all the reverses he may suffer by reason of using the wrong grade of iron.

A furnaceman should do all he can to advertise and define the true chemical and physical properties of his iron. When he has done this, the founder is the one to decide what furnace makes the iron best suited to his work. To assist furnacemen to set forth the chemical and physical properties of their special brands or grade of iron, so that founders may intelligently choose for themselves, Mr. Church has, in presenting "Analyses of Pig Iron," brought out a work that is very valuable to the trade.

It is as important for furnacemen to set forth the character of the iron they make as it is for a rolling mill or steel works to advertise the class of material they manufacture. This is coming to be more fully recognized, and the day is not far distant when, instead of the author of such a work as Mr. Church's soliciting a correct and intelligent description of pig iron, furnacemen will seek such advertising mediums.

Many have condemned the practice of working by chemical analysis, on account of sometimes finding that results do not agree with the reported analysis as expected. This is not the fault of chemistry, but is often caused by ill-mixed casts of pig-iron or errors of the chemists, or in not obtaining a fair sample of the furnace cast, pile or car of pig. Then, again, in errors they may have made in transferring records of analysis which have generally to pass through several hands before they reach the founder. Such mistakes as the latter are clerical errors that can occur in any line of keeping accounts. Because furnace casts are not uniform in their chemical composition, no one should condemn the utilization of chemistry in making mixtures of iron. There are ways to guard against mistakes as above occurring, and the one who studies to discover them will find that chemistry is a true and exact science in defining the grade of iron or guide the making of mixtures. Chemistry is so true a science that if correctly applied, any founder may go on making analyses week after week and year after year in making mixtures, and never have one heat fail to any radical degree to give the physical results desired in castings, something that is impossible to be attained if guided wholly by the appearance of pig iron fractures.

To insure accuracy in making mixtures, the first factor of importance is to obtain a uniform and well-mixed cast of pig iron, as where one end of a furnace cast differs to nearly one per cent in silicon and one to three points in sulphur, as it often does, and the cast is not mixed thoroughly, it is impossible to expect a uniform mixture, from the cupola, no matter how true the analyses may have been. A furnace cast or pile of iron, can with a little study and care, be mixed so thoroughly, either at the furnace in loading the cars or at the foundry in unloading them, that any half dozen pigs taken from any part of a pile in the founder's yard or on the cupola's staging will represent a very close average of the whole furnace cast. If a founder takes iron out of a car having one end from .75 to 1.00 per cent higher in silicon than the other, and a wide variation in sulphur to charge into one heat or part of such, and then takes the other end for more of such meltings, he must have a great difference in the hardness or softness of his castings, and with many founders cause them to find fault or condemn the iron. Such ill-mixed casts of pig iron have often been the cause of complaints and puzzled the furnaceman to understand why fault should have been found with his iron. A little study of this factor will cause furnacemen to realize that in many cases it was as much to his interest as to the founder, to make sure that a cast of pig iron is uniform one end with the other before it is charged into the cupola.

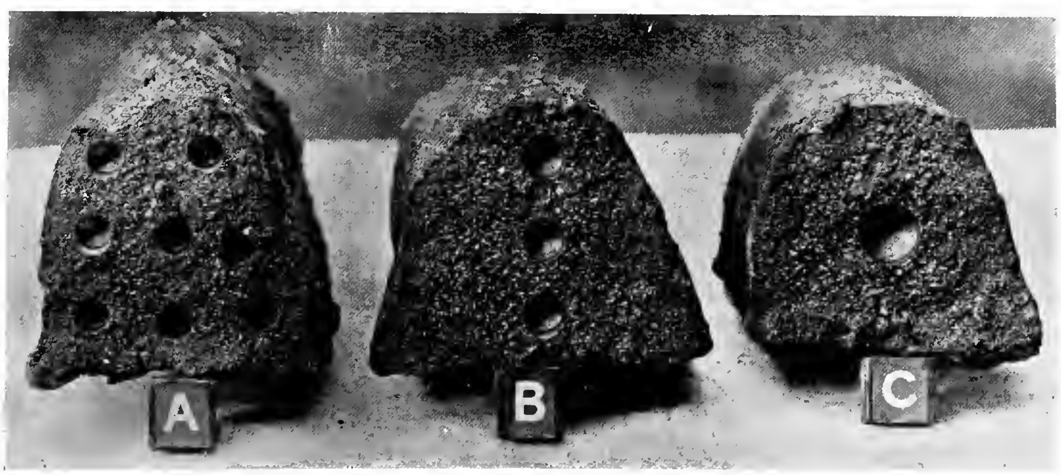


Figure 1.

While it is important to have a well-mixed cast of pig iron, it is also as important that it is sampled properly in obtaining drillings for making analysis, and again, to take the best measures practical to guard against errors in making and reporting analysis. The best way to do this is for every founder to not only exact an analysis of each furnace cast that he uses, but upon receipt of the iron, at his yard, to then have another analysis made to check that of the furnace, and discover if any mistakes have been made. If a furnace analysis is in error but one heat a month, it often pays well to have every car of iron analyzed before using it, as one heat gone wrong, or not giving the right grade of iron in castings, can, in many cases, cause the cost of six to twelve months analysis of every car of iron a founder may receive from furnaces.

In taking samples for obtaining drillings to represent a fair average of the composition of a cast of iron, six to ten pieces of pig should be selected from a car, care being taken to select them from different sections, so as to make as good an average of the car's or cast's grade as is practical. The pieces need not exceed a quarter of a pig in length, and in drilling them, the utmost care should be taken to prevent sand or scale from the pigs getting mixed with the drillings. The drillings are taken from the fractured face of a pig, as seen by the holes in Fig. 1, with a flat drill. A twist drill gives a large variation in the size of borings, according as the hardness of the iron varies. Some drill six to ten holes to obtain samples as at A, and again, others drill as at B, having three holes, but C with only one hole in the center is the plan followed by many in obtaining analyses or checking reports, and which, for general run of work, excepting the carbons, answers all practical purposes. In cases of carbons, or where the greatest accuracy is desired with the other elements, pigs are best drilled as at A or B, and the drillings from each hole should be kept separate, and after the drilling is completed the same weight of drillings from each hole should be taken and the whole mixed together as thoroughly as possible, to obtain an average. For each analysis about one teaspoonful of drillings are ample for any of the elements, and such are best passed through a 20 or 40 mesh sieve before being used. To do this it may often be necessary to pulverize the drillings in an iron mortar.

Aside from the problem of proper sampling of pig iron to obtain a fair sample of drillings, we have that of the chemist requiring means of knowing if his chemicals and methods are correct. Almost every trade or calling possesses some means by which its artisans can tell whether their labors have been productive in obtaining the perfection desired. A trial of a perfected machine or engine shows the machinist or engineer the perfection he has attained. The appearance of the finished castings indicates to the furnaceman or founder the results obtained from his irons, but the completion of an analysis by a chemist presents no tangible evidence of the accuracy of his results. The only way a chemist can know the correctness of his results or give others the best assurance that his work is correct is by having them checked, or by analyzing drillings that have been determined by competent chemists to find whether results agree. The latter process is, in a sense, a method of checking similar to the use of standard weights to test the accuracy of scales, and no laboratory is complete without its standards any more than a furnace or foundry would be without standard weights for occasional testing of their scales, thus showing that the chemist left without means to check his work is, in a measure, like one working in the dark. This the writer proved to be the case about three years ago, by sending out samples of the same drillings that had been thoroughly mixed, to about twenty different chemists, and whose results varied so greatly as to show the difference seen in Table No. 1.

TABLE 1.

GREATEST VARIATION IN ANALYSES ON ONE SAMPLE IN CHECKING DRILLINGS.

	Sil.	Sul.	Phos.	Mang.	C. C.	G. C.	T. C.
Mr. Johnson's variations..............	.19	.028	.029	.19	.33	.82	.48
Mr. West's variations..................	.21	.015	.031	.23	.59	.77	1.09

About a year after the writer had obtained the results shown in the above table, one Mr. Edmund E. Johnson, then chemist of the Ashland Iron and Steel Co., Ashland, Wis., sent out samples to about fifty chemists, in hopes to obtain more uniform results than those obtained by the writer. But, as seen by a comparison of results, Mr. Johnson was no more successful than the writer. However, if to-day one would send out samples of the same composition to a number of chemists he would, without doubt, obtain much more uniform results. This is due to there now being over two hundred of our leading laboratories using the American Foundrymen's Association's standardized drillings, a sample case of which is shown in Fig. 2. The

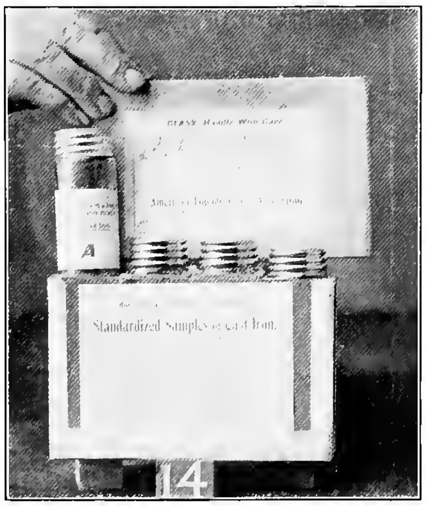


FIGURE 2.

committee having charge of this work, and of which the writer is chairman, have also been laboring to establish the adoption of more uniform methods for making analyses, and have created such an interest in this work as to cause a special committee to be appointed at the A. F. A. Convention, June, 1901, to labor for success in this line. With the assistance of the A. F. A.'s standardized drillings and the adoption of more uniform methods in determining analyses, we may then expect very close results on any one sample analyzed by different chemists. This is sure to come, and is an advance all will warmly welcome.

UTILIZATION OF DIFFERENT GRADES IN MAKING MIXTURES.

Another factor which the advance of chemistry in founding has had to contend with is the idea that the iron a furnaceman furnishes a founder should be all exactly of the same grade or analysis that was necessary in his castings. For example, if the castings required a soft-

ness such as a 2.00 per cent silicon iron in the cupola would give, some founders seem to have the idea that they must have an all 2.00 per cent silicon iron, and that any irons higher or lower in silicon would not do. The main point in this matter that calls for exactness lies in the brand of iron used. If, for example, a founder should have charcoal iron, then coke iron could not be used and vice versa, but in the same brand, a founder should be able to use almost any percentage of silicon as long as some is high enough to permit mixing with low silicon iron to get the average that will give the grade desired in the casting. As an example with a few hundred of 4.00 to 16.00 per cent of silicon iron, a founder may be able to often use a ton or two of iron having only one per cent or less of silicon. The same is to be said of variation in sulphur, as of silicon. If the former is too high, then more silicon will be required in the mixture, or its evils can be remedied by mixing low sulphur iron with the high, if such can be obtained. The same rules hold good in obtaining averages of carbon, manganese or phosphorous in making mixtures.

To describe some methods of computation that will permit the use of varying percentages of silicon, sulphur, etc., in making mixtures, Tables 2 to 5 are presented. These illustrate the use of three different brands and grades of pig iron, and two of scrap that give a mixture which averages 2.00 silicon, .034 sulphur, .53 manganese, .42 phosphorous, and 3.66 carbon, as shown in Table 4.

In Table 2 is shown a method of obtaining averages by multiplying the weight of the iron by its percentage of silicon. Another method sometimes used as a check or alone is to divide the weight of each brand or grade of iron into percentages, after the plan seen in Table 5. Here we find that the total of 100 parts gives us 2.00 silicon, the same as obtained by methods in Table 2.

We have not shown the process of computing the averages of the sulphur, manganese, phosphorus or carbon in a mixture. These elements are obtained by the same rule as used for the silicon, seen in Tables 2 and 5, and any desiring to test this can do so by computing any of the various elements seen in Table 3 and comparing them with the results shown in Table 4, which are the averages of all the metalloids in the mixture as it stands ready for charging into the cupola.

In obtaining the average percentages of the silicon, manganese and carbon, they are figured to the second decimal, and the sulphur and phosphorus to the third decimal.

TABLE 2.

COMPUTING THE SILICON.

Brand and Grade of Iron Used.	Weight of Iron Used.		Percentage Silicon.		Total Points of Silicon.
No. 1 Johnson.........	800-lb.	×	2.90	=	2,320.00
No. 4 Emerson........	600-lb.	×	2.00	=	1,200.00
No. 6 Jackson.........	500-lb.	×	1.62	=	810.00
Shop Scrap............	400-lb.	×	1.90	=	760.00
Yard Scrap...........	700-lb.	×	1.30	=	910.00
	3,000-lb.				6,000.00

6,000.00÷3,000=2.00 per cent of silicon.

TABLE 3.

PERCENTAGE OF SULPHUR, MANGANESE, PHOSPHOROUS AND CARBON IN THE IRON.

Brands and Grade of Iron Used.	Weight of Iron Used.	Sulphur.	Manganese.	Phosphorous.	T. Carbon.
No. 1 Johnson	800 lbs.	.01	.50	.60	3.20
No. 4 Emerson	600 lbs.	.02	.60	.30	3.60
No. 6 Jackson	500 lbs.	.03	.70	.20	3.80
Shop Scrap.............	400 lbs.	.05	.50	.40	3.90
Yard Scrap...............	700 lbs.	.07	.40	.50	4.00

TABLE 4.

RESULTS OF COMPUTATION OF TABLES 2 AND 3.

6000.00 parts silicon	÷ 3000 lbs.	=	2.00	per cent silicon
104.00 parts sulphur	÷ 3000 lbs.	=	.034	per cent sulphur
1590.00 parts manganese	÷ 3000 lbs.	=	.53	per cent manganese
1270.00 parts phosphorous	÷ 3000 lbs.	=	.42	per cent phosphorous
11000.00 parts carbon	÷ 3000 lbs.	=	3.66	per cent carbon

TABLE 5.

METHOD OF CHECKING TABLE 2.

Brand and Grade of Iron Used.	Per cent of Iron Used.		Per cent of Silicons.		Total per cent of Silicon in 100 parts.
No. 1 Johnson	$26\frac{2}{3}$	×	2.90	=	77.33
No. 4 Emerson	20	×	2.00	=	40.00
No. 6 Jackson	$16\frac{2}{3}$	×	1.62	=	27.00
Shop Scrap............	$13\frac{1}{3}$	×	1.90	=	25.33
Yard Scrap............	$23\frac{1}{3}$	×	1.30	=	30.34
	100 parts				200.00

One part equals 2.00 per cent silicon.

CHANGES EFFECTED BY REMELTING IRON.

Having shown methods for obtaining the averages of elements in iron before charging, it follows to show the changes that occur in remelting the iron. In a general way, the silicon, manganese and graphitic carbon are decreased, while the sulphur, phosphorus and combined carbon are increased. The total carbon may be slightly decreased or greatly increased. The lower the total carbon, the greater the heat and longer the iron is in passing from a cold solid to a fluid state, the more favorable are conditions to increase the carbon. The writer has, in some experiments, increased the total carbon by five remelts of the same pig iron from 3.94 to 4.76, an increase of nearly one per cent. While this shows that carbon is increased, there may with high carbon and silicon irons be conditions which decrease the carbon.

Silicon is invariably decreased. The greater the amount in the iron, and the higher the temperature and pressure of blast, the greater the decrease. The loss generally ranges from .15 to .30 per cent.

The increase of sulphur is due to the sulphur in the fuel, and will range from 2 to 6 per cent of the sulphur in the fuel. The more manganese in the iron and the more a cupola is fluxed or slagged, the less tendency there is for iron to absorb sulphur from the fuel. While, on the other hand, the longer the semi-fluid and liquid iron stays in the cupola, all other conditions being equal, the more sulphur is absorbed by the iron. As an approximate, make an

allowance of about 4 per cent of the sulphur in the fuel to be absorbed by the iron. This would mean that with about .80 in the fuel, an iron having about .02 before being charged would have, after being remelted, about .05 of sulphur in the castings, an increase of about .03 points.

Manganese is decreased according to the degree of temperature and the length of time iron remains in the cupola. The loss varies from .15 to .25 per cent, and is closely in keeping with the loss in silicon.

Phosphorus is increased according as its percentage exists in the fuel. Iron possesses a great affinity for phosphorus, similar as for sulphur. However, as it takes over .10 phosphorus to effect the grade, which is far more than that absorbed by the iron in remelting it, little notice is required in making allowances for the increase of phosphorus in making mixtures.

Graphitic carbon is decreased and combined carbon increased by reason of the loss of silicon and increase of sulphur. Continued remelting from four to six heats can so decrease the graphitic carbon and increase the combined carbon as to cause a No. 1 or soft iron to become a No. 10 or white iron. (See Table 8, page 24, for grading numbers.) It is for this reason that shop scrap or castings coming from any heat is always harder than the composition of the mixture as charged into the cupola.

EFFECTS OF METALLOIDS ON CAST IRON.

Cast-iron is a metal which possesses greater peculiarity and is more complex than any of the common metals in commercial use. The greatest factors causing cast-iron to be so peculiar and complex a metal, are due to the variations which can be caused in its color and grain by varying its chemical constituents, or rate of cooling from a molten to a cold state.

Chemistry shows the constituents of cast iron, to consist generally of from 92 to 96 per cent of metallic iron, and the other 4 to 8 per cent to consist chiefly of the impurities, carbon, silicon, sulphur, manganese and phosphorus. Aside from these, the iron may contain small percentages of titanium, copper and arsenic, together with other elements which may be effective in controlling physical properties to a slight degree. However, it is by changes in the percentage of silicon, sulphur, manganese and phosphorus that chiefly regulates variations in the physical properties of mixtures of iron.

The carbon in iron is obtained from the fuel used in making the iron. Coke and anthracite coal, also charcoal, are the fuels now used, anthracite being little used except in mixture with coke. The carbon is all held in a chemically combined form in iron, while it is in its hottest molten state. When the iron is solidified the carbon is chiefly separated into two forms, called combined and graphitic carbon. When the carbon is almost wholly combined, the solidified iron shows a white color and very dense or no grain. When it is more in the graphitic or free carbon form, it shows a grey color, and can have a very open grain. Sometimes metal will be so long cooling that the carbon will partake so strongly of the graphitic or free form, that loose flakes of graphite can be picked out from between the grains of the iron, or removed with a brush, and change the color from a rich dark to a grayish white. It is nothing unusual about blast furnaces to find the ground covered with flakes of graphite or commonly called " kish " that has been given off by molten metal as it was cooling while running down the pouring runner or standing in a ladle. This character of iron is generally higher in carbon than the metalloids favoring softness will allow to combine with the iron, and hence in its cooling it is expelled in the kish or flake form described. The more graphite can be picked or brushed out from between the grains, as above described, the weaker is the iron. It is on account of the slower cooling of large bodies causing the evolution of graphite that they do not

possess the strength per square inch of small bodies, holding the carbon more in a combined form. While this is true, it does not follow that if we could keep the carbon wholly in a combined form, that we would then obtain the strongest results. This could cause large bodies of iron to closely approximate the strength of small ones made from the same iron, but would give a much weaker metal. In the main, this is due to there being a certain point at which the presence of graphite proves beneficial to strength. This point is shown by analysis in numerous tests, to have the total carbon divided so as to have the graphite range from about one-third to one-half that of the combined carbon, the best point depending upon the special character of the iron as what may be best for one brand would not be so for another, or different percentages in the metalloids.

The amount of carbon that iron will absorb as made for general foundry use, ranges from 2 to 4.50 per cent. Much depends upon the working condition of the furnace and the percentage of silicon, sulphur, manganese and phosphorus taken up by the iron when being made. Silicon reduces the power of iron to absorb carbon, while manganese has the opposite effect. However, whatever is the percentage of carbon in iron, it is the king element to which all others are but as tributaries in causing it to make changes in the physical properties of the iron. We will now proceed to describe the part that changes in the silicon, sulphur, manganese and phosphorus play in causing the carbon to take the combined or graphitic form to effect the physical properties of iron.

The element under greatest control of the founder which causes the carbon to take the combined or graphitic form aside from rapid or slow cooling is silicon.

The value of silicon as a regulator in changing the grade of iron was first suggested by Dr. Percy, about forty years ago. It is a metal or commonly called metalloid that is imparted to iron by both the fuel and ore, and can be absorbed by iron as high as 20 per cent. It requires more fuel and higher temperatures to make high silicon than low silicon iron, and where more than 4 per cent silicon is required in an iron, higher silicious ores are used. Any increase of silicon in iron to 4 per cent will soften it or increase the graphitic carbon, but above this amount, it can harden iron or increase the combined carbon. As a rule, more than 3.50 per cent silicon in any casting will decrease its strength, and in castings more than 1″ thick often cause them to be very brittle unless the iron is very high in sulphur, which hardens iron, as described later on.

Silicon not only softens iron, but it also increases the life and fluidity of molten metal. The silicon in foundry or charcoal irons ranges from about .75 to 3.50 per cent, the latter iron generally possessing less than the former of silicon, although we have charcoal irons possessing 5 per cent silicon. In bessemer iron, which differs from foundry iron, in having phosphorus not exceeding .10, the silicon ranges from .75 to 2.50 per cent. Ferro-silicon iron contains silicon from 5 to 16 per cent. This latter metal possesses a silvery, flaky, frost-on-the-window appearance. It has very little strength, and is generally used to mix with low silicon irons to soften them, or to cheapen mixtures.

Sulphur in iron is chiefly derived from the fuel used in making the iron and in remelting it in a cupola. Its influence is to create combined carbon or harden iron. It takes by far the least of this metalloid to affect changes in the grade of an iron than any other element. One part of sulphur can be more effective in changing the grade of an iron than 8 to 12 parts of silicon. We may, by a radical increase of silicon or manganese greatly counteract the effects of sulphur, if not allowed to exceed .10 in the casting. Sulphur is absorbed by iron up to .30 per cent. If sulphur is allowed to exceed .20 per cent in iron it is sufficient to injure almost any casting made, excepting such as sash weights. Where sulphur is high in iron it can cause blow-holes in castings. Such may also prevent castings from run-

ning sharply when pouring moulds on account of it causing metal to be sluggish and solidify rapidly.

Charcoal iron, on account of being made from a fuel freer of sulphur than coke, contains less sulphur on an average than coke iron. In grey iron, made with coke, the sulphur will generally run from .01 to .04. A white or very low silicon coke iron may contain sulphur from .06 to .30, whereas, it is rare to find any charcoal iron possessing sulphur over .025; it generally ranges from .005 to .025. As a rule, the higher the silicon in any pig iron, the lower the sulphur. While this is true, there are times when the sulphur will be high as well as the silicon in pig iron.

The sulphur in fuel used in cupolas with mixtures for soft castings, etc., should not exceed .80, as over this is very effective in radically increasing the sulphur in iron, and which can so harden the iron as to render light castings useless. With the exception of some kinds of desired chills or hard iron castings, where high sulphur may be permissible, it is very injurious and an element which founders would very much like to dispense with.

Manganese in iron is derived from the ores. Its general influence is to create combined carbon or harden iron, similar to a degree as with sulphur. Manganese possesses a great affinity for sulphur, and can eliminate it greatly from iron, if sufficient is used in mixtures. It ranges from .10 to 3.00 per cent in grey pig iron. It generally averages about .50 in ordinary foundry charcoal or bessemer iron. It is an element well under the control of a furnaceman in giving any desired percentages in the iron. A peculiar effect of manganese lies in that it often causes the grain of pig iron to look coarse and soft, but when tested with a chisel or drill is found to be very hard. It gives some fluidity and good life to molten metal, and is a constituent that has proved of much value in the manufacture of castings.

Phosphorus is obtained from the ore flux and fuel. It has a great affinity for iron, and is hard to eliminate. It is generally found from .03 up to 1.00 in pig iron, although it has been found as high as 7 per cent in iron. Its influence is rather neutral compared to the other elements in causing the carbon to take a graphitic or combined form as found in ordinary iron. It can be made to strengthen iron if not allowed to exceed .60, but over this amount its influence is to weaken iron. When phosphorus is used in excess of obtaining the best strength it can be carried up to such an extent as to be the most weakening element that iron possesses. It excels all other elements for adding fluidity and long life to molten metal. Necessity for extra fluidity or long life is about the only reason that it is ever wise to have phosphorus exceed .80 in castings.

TABLE 6.

CHARACTER OF SPECIALTIES MADE OF CAST IRON.

1. Toys and statuary.
2. Locks and hinges.
3. Stoves and heating furnaces.
4. Hollow ware.
5. Bath tubs.
6. Furniture castings.
7. Piano plates.
8. Dynamos and electrical castings.
9. Small pipe-fittings and valves.
10. Radiators.
11. Pulleys.
12. Wood-working machinery.
13. Weaving machinery.
14. Farming implements.
15. Moulding machines.
16. Fans and blowers.
17. Printing presses.
18. Journal boxes and shaft hangers.
19. Lathes, planers, etc.
20. Street lamps and hitching posts.
21. Water and gas pipes.
22. Sidewalk grating and man-holes.
23. Furnace and floor plate castings.
24. Sash weight.
25. Architectural work castings.
26. Pneumatic hoists and machinery.

TABLE 6—Continued.

27. Gas engines.
28. Freezing machinery.
29. Air brakes and railroad castings.
30. Steam pumps.
31. Hydraulic cylinders and machines.
32. Steam and blowing engines.
33. Hand and machine moulded gears.
34. Mining machinery.
35. Punch, shears and dies.
36. Ingot moulds and stools.
37. Annealing pots and pans.
38. Shot, shell and cannon.
39. Chilled car wheels.
40. Sand and chilled rolls.

Aside from the above classification, there are a great variety of light and heavy castings used in a thousand and one different forms in the miscellaneous construction of castings. The above list gives us about forty different specialties, almost all of which calls for different grades or mixtures of iron, some of which differ very radically. The specialties ranging from No. 1 to No. 9 generally call for variations according to their thickness, in what is known as the softest grades or mixtures of iron. Those ranging from 10 to 22 generally require medium soft grade of iron. No. 23 can be made of medium soft grades of iron somewhat harder than permissible in the numbers above it. No. 24 is made of the poorest refuse of iron, and consists often of old rusty stove plate, burnt iron and tin sheet scrap, a mixture which generally gives a white and brittle grade of metal. No. 25 to 29 is a class of iron that generally requires a different mixture and a harder iron than those ranging from No. 10 to 22. Nos. 30 to 35 are specialties which generally call for strong grades of iron as will permit of finishing in lathes, planers, etc. As a rule, strong grades of iron can be made so hard as to make it difficult to turn or plane it in finishing castings. Charcoal iron is often largely used in the latter grades, wherein from Nos. 1 to 29 it is rare that such is used, as coke iron can generally be made to answer all purposes. Nos. 36 and 37 require a grade of iron very distinct from the other specialties shown, owing to such casting having to stand changes in radical variations of temperature, or such as causes an action of alternate expansion and contraction while the castings are in use. Iron of a medium soft character and low in phosphorus or what is termed regular bessemer is found best for such castings. No. 38 calls for a grade of iron that should be both of a hard nature and strong. These castings are generally made from the best brands of charcoal iron. Nos. 39 and 40 are made of what are called chillings irons, and which may be composed of charcoal or coke irons mixed, or of all charcoal. The rolls are best made of iron melted in an air furnace, although some are cast of iron melted in a cupola. Chilling iron differs most radically from the grades or brands generally used in the specialties Nos. 1 to 38. Sometimes from 10 to 30 per cent of soft steel scrap or good grades of wrought iron is mixed with cast-iron to increase its strength or chill, and which, if intelligently used is generally effective to such an end.

PHYSICAL PROPERTIES OF CAST IRON.

One great peculiarity of cast-iron is that there is often considerable difference in the physical properties of different brands or grades of iron possessing practically like analyses, as far as the carbon, silicon, sulphur, manganese and phosphorus are concerned, and similar treatment in cooling had been accorded them. It may be that a deeper research by analyses, extending it to determine the titanium, copper, arsenic and other minor constituents, combined with microscopical researches, would explain some things which many are at a loss to understand. However, the fact remains that chemistry does not account for many of the peculiarities often found in different brands and grades of iron. For this reason it is often necessary

to make physical tests in connection with chemical analyses, in order that one may be assured of any special physical properties contained in an iron. Some furnaces make an effort to remelt samples of their casts in small cupolas, and make test bars to give them the strength, deflection, chill and contraction of their irons. Such a practice is often commendable and of much value to the trade.

In using test bars, to obtain the strengh and deflection, the best is the round form, cast on end. The diameter is best not smaller than 1½″ for soft grades, 2″ diameter for medium grades, and 2½″ diameter for hard or chilling irons. All bars should be 14″ long and broken on supports 12″ apart. This was decided by a committee of the American Foundrymen's Association, of which Dr. R. Moldenke is chairman, after making over 2,000 test bars in sizes ranging from ½″ square and round to 4″ square and round, in ten different grades or specialty mixtures, which comprised about two tons of test bars in each set of 200 bars, each set being poured from one ladle within twenty-five seconds. Thus, all bars of any one set, about 200 in number, were cast with metal of like temperatures, an achievement which is highly commended by practical founders, familiar with the success attained.

The achievements of the A. F. A. committees in establishing standardized drillings in over 200 laboratories and in finishing this great work of obtaining over 2,000 tests in ten grades of iron, has encouraged the Society to undertake additional work in the matter of endeavoring to establish greater uniformity in methods for making analyses and grading pig iron, so that one can tell from market reports or the purchases of No. 1 iron whether he is going to get an iron having 0.50 or 4.00 per cent of silicon in it. The chart seen at Fig. 3 shows the variations in numbering iron that was compiled from the first edition of Mr. Church's work, "Analyses of Pig Iron," and presented in a paper by the writer, appealing for a remedy to the Pittsburg Foundrymen's Association, March 6, 1901. To permit readers of this volume an opportunity to understand the gist of this paper, the following extracts are given:

ERRATIC AND SYSTEMATIC GRADING OF PIG IRON BY ANALYSIS.

In these extracts it is intended to call attention to the present rather erratic methods adopted in grading pig iron by analysis, and to deduce principles whereby standards for such grading could be established. In this way a fair idea could be formed in regard to the physical properties which may be expected from different brands of pig iron, wherever they are referred to by numbers. The erratic and unsound manner in which the grades of different brands of pig iron are now numbered cannot be better brought out than is done in the first edition of "Analyses of Pig Iron," by Mr. Seymour R. Church. In this work, we find pig irons called No. 1 by their makers and ranging in silicon from one-half of one per cent (.50) to four per cent (4.00), furthermore the wildest kind of confusion as to numbers and trade-marks, etc., supposed to designate special qualities in the different grades of pig iron reported.

To illustrate the present impracticable meaningless habit of numbering grades of pig iron when grading and selling by analysis, the writer presents a chart, Fig. 3. Every line stands for a range of one-fourth of one per cent in silicon in the composition. The length of the heavy black lines represents the relative number of analyses giving the different percentages of silicon in irons called No. 1, as found in the first edition of "Analyses of Pig Iron." Coke irons are shown on the left and charcoal irons on the right. It is to be understood that this paper is not a criticism on the first edition "Analyses of Pig Iron," but rather on the absence of method and standards in grading of pig irons by analysis.

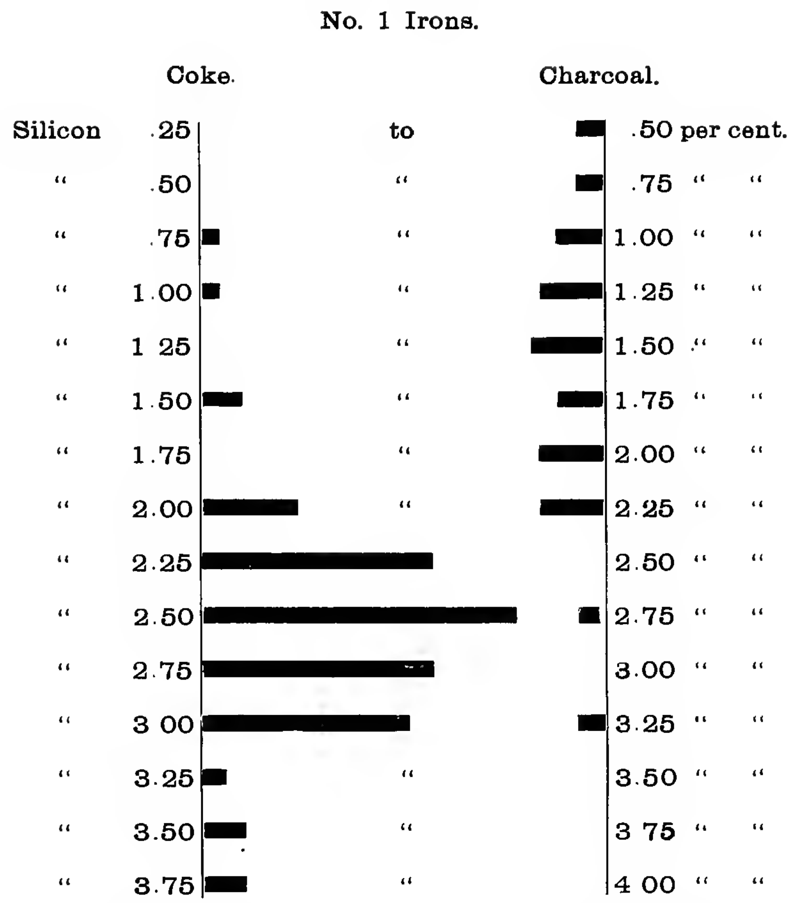


Chart showing erratic grading of Pig Iron in 1900.

Fig. 3.

The general conception by foundrymen of a No. 1 pig iron is that it refers to that grade of iron which is best adapted, when melted by itself, to give soft iron in castings ranging from one inch thickness down to stove plate. Then, again, genuine No. 1 iron is more expensive to make than a No. 2 or No. 3. This is due to the fact that a No. 1 iron should contain more silicon than a No. 2 or No. 3. The higher the silicon, the more fuel is necessary to make it. When we read the market reports of pig iron prices, we generally see them quoted as No. 1, No. 2, No. 3, etc. If one furnaceman calls an iron containing but .50 per cent of silicon a No. 1 iron and another calls a 4.00 per cent silicon iron No. 1, what is one to understand by such terms, and what endless confusion and loss must not such a practice cause?

Furnacemen are not the only ones to blame when their customers receive iron not suited for their purpose. Unfortunately too few buyers know what they should use, and hence, between the two, there is much to be remedied. However, the writer looks for the day when almost, if not all irons will be shipped just where they will do the work they are best suited for. This cannot be fully realized until furnacemen will not only furnish chemical analyses as they now do, but also physical tests of their respective brands and grades after it has been remelted in a small cupola.

All progressive furnacemen and founders now work under the rule that silicon and sulphur are the elements which control the grading of iron by analysis, ores, flux and fuel being similar. This principle was first advocated by the writer in his work "Metallurgy of Cast Iron." It also allows the devising and establishing of standards in grading pig iron by analysis which can be adhered to by all furnaces making irons ranging from .50 to 3.00 per cent in

silicon. The line of distinction between grades should be drawn so that the amount of silicon and of sulphur which can make a perceptible change in the hardness of castings when pig iron only is remelted is taken into account.

The writer's extended experience obtained by closely following variations in the hardness of castings due to changes in silicon and sulphur, is such that he can safely say that where sulphur is kept constant, every increase of .25 per cent in silicon will perceptibly change the hardness or grade of castings in all iron ranging up to 3.00 per cent in silicon.

It takes less sulphur than any other element to effect a change in the grade or hardness of a casting. A change of one point of sulphur (.01 per cent) can neutralize the effect of eight to twelve times the amount of silicon. This will be better understood by reference to Table 7, which shows approximately the increase in silicon and sulphur necessary to maintain a uniform hardness (or a constant condition of the carbons) in remelted pig iron. This can only be observed by melting pig iron in a cupola at the furnace or in the foundry, to make test bars or castings. In brief, Table 7 shows that if an iron containing 2.00 per cent silicon should have its sulphur increased from .01 to .06, that in order to maintain an approximated equal hardness in similar test bar or castings, the silicon would have to be increased .50 points.

TABLE 7.

Sulphur	.01	.02	.03	.04	.05	.06
Silicon	2.00	2.10	2.20	2.30	2.40	2.50

As a rule in coke irons the lower the silicon the higher the sulphur. In establishing standards the amount of sulphur, therefore, should be considered as well as the silicon. Recognizing this fact in connection with the statement given above, which makes a distinction in grade at every .25 per cent of silicon, Table 8 is presented for consideration in discussing standards for the numbering of grades. One may thus form some fair idea of the hardness to be expected in castings from pig iron when ordering No. 1, 2, or 4 in different brands of iron, to obtain an average for a mixture to be figured after the methods seen in Tables 2 to 5, pages 16 and 17.

TABLE 8.

	No. 1 Iron.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	2.75 to 3.00	2.50 to 2.75	2.25 to 2.50	2.00 to 2.25	1.75 to 2.00
Sulphur	.01 to .02	.01 to .03	.01 to .03	.01 to .04	.02 to .04

	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
Silicon	1.50 to 1.75	1.25 to 1.50	1.00 to 1.25	.75 to 1.00	.50 to .75
Sulphur	.02 to .05	.03 to .05	.03 to .06	.04 to .07	.04 to .10

Numbering the grades from No. 1 to No. 10, advancing in silicon .25 and sulphur .01 to .03 or more in each grade, as shown in Table 8, gives a range that may be said to include all the necessary ones that are now used in making castings, except the so-called softeners or ferro-silicons. It will be noticed that the suggestions for grading pig iron as given herewith arbitrarily starts with No. 1, an iron containing from 2.75 to 3.00 per cent of silicon. The majority of furnacemen happen to grade pretty closely to this standard, as is shown by Fig. 3, which gives the greatest numbers of irons graded as No. 1 as containing 2.50 to 2.75 per cent in silicon.

When purchasing ferro-silicons or softeners, their full composition should be obtained, as indeed should those of any grades in No. 1 to No. 10 irons given in Table 8, so that when

using any of the grades by these tables they could be handled intelligently and give the founder a chance to compute an average of the different grades it may obtain to secure exactly or very closely the quality desired in his castings.

The phosphorus, manganese, and carbon contents, it will be noticed, are not touched upon in any of the above tables. These are ingredients which are fairly constant in all brands of iron made from similar ores, fuel, and fluxes, and what slight changes may occur in them can affect the grade of any brand of iron very little. While this is a fact, it would generally be advisable for furnacemen in advertising their irons to state along with the brands named, what percentage of phosphorus, manganese and total carbon, their iron contains, as there are conditions demanding varying percentages of these elements met with that would enhance the irons were these points made known. As for example, a founder making very thin castings would require higher phosphorous, which gives more fluidity to iron, than is available in some regular No. 1 grades. Then, again, it is often necessary to know what manganese an iron contains, as when it is more than .50 its influence is to harden. With regard to the carbon, the " total " is all that is generally required. Giving the percentage of what is combined or free carbon in pig iron tells nothing further than the melting qualities of the metal. In this the more the carbon is combined, the easier or quicker the iron melts, a fact discovered by the writer several years ago and confirmed by Dr. R. Moldenke, by further experiment. If a knowledge of the combined or graphitic carbon contents of pig iron was of any real value in grading pig irons by analysis, grading could be done effectively by fracture or hardness and the only determinations required would be those of the total carbon, phosphorous, or manganese, accordingly as information might be desired of one or all of these ingredients. Where information of these elements were not necessary their analyses could be ignored entirely.

By bringing forward the suggestions herein outlined for grading pig iron by analysis, a way is opened up whereby it is hoped that much good will result. This is a good subject for discussion by furnacemen as well as founders and would be adapted for further ventilation at the coming convention of the American Foundrymen's Association where the greatest number of those interested would meet.

A copy of the above paper with discussion thereon, was sent out to a large number of furnaces and foundries, accompanied by a circular having the following questions:

1. Do you approve of the establishing of more uniform methods for grading pig iron by analyses? ....

2. Do you endorse the method outlined by Mr. West's paper? ....
....

3. If not, please state your opinion as to what division of the silicon, sulphur, etc., you think best in the grading of pig iron, and state what views you hold on this subject which you would like to have considered at the Convention.

....
....

The above blanks were sent out by Dr. R. Moldenke and the writer as chairman, which committee was appointed by the Pittsburg Foundrymen's Association to forward the interests of the work and report advancement to the American Foundrymen's Association's Convention, June, 1901.

Two-thirds of the large number of replies received answered questions 1 and 2 in the affirmative; the other third endorsed question No. 1, and replied to No. 3 by presenting different views, and in some cases forms of methods, etc., for grading, all of which were presented to the Convention, 1901.

Some expressed themselves as thinking that the methods advanced by the writer shown in Table 8 would grade too closely, and was something that could not be carried out in practice. These sentiments showed that the plan advanced had not been understood. It is not intended that a furnaceman shall be confined to furnishing one of the grades shown in Table 8, but that in ordering iron the founder should specify the exact grade he desired by the numbers shown in Table 8, and then the furnaceman might send two to four grades, if necessary, to give the founder an average that would comply with the grade he had designated. These different grades would then in turn be mixed after the methods to obtain an average mixture, shown by Tables 2 to 5, pages 16 and 17. As a rule, all furnacemen prefer not being confined to any special analysis in the silicon and sulphur, so as to permit them to ship irons varying in silicon and sulphur from which the founder can obtain the average he desires to give a definite percentage of silicon and sulphur in his mixtures. There is nothing in Table 8 to prevent such a practice, and it was with a view of permitting such that the writer presented the method shown. As all answered question No. 1 in the affirmative, there is every reason to believe that we shall have something before many years roll by that will be a great improvement over having an iron .50 and another 4.00 in silicon graded as a No. 1 iron. At least it is felt that the agitation of the subject was timely, and many will be pleased to note its continuance here, as such should help the cause.

THOMAS IRON.

A BIT OF HISTORY.

Written by Mr. F. H. KNIGHT, Assistant General Superintendent Thomas Iron Company, Hokendauqua, Pa., especially for this publication.

The history of metallurgy in America is replete with great deeds none the less creditable because of performance in the act of peace rather than in war or state. The dazzling magnitude of modern plants, the outgrowth of such vigorous Americanism pay eloquent tribute to those master minds who conceived and contributed their quota to the great result—the Age of Steel.

To make this era a possibility, was the work of those whose lives and energies were devoted to the successful manufacture of pig iron, and Smeaton the inventor of the modern blowing engine, Neilson who first saw the advantage of the hot blast, and Du Four who first applied the tunnel head gases to a practical end, were all men whose contributions were valuable, and their fame justly heralded.

Contemporary with these, was one who, in a quiet and less assertive way, first practically combined with his own, the theories of his contemporaries, and thus, after years of persistent trial, finally blazed the way to success in the use of anthracite coal for the smelting of pig iron.

David Thomas, son of David Thomas farmer, of Tyllwyd, Glamorganshire, South Wales, was born November 3, 1794. Something more of a student than a farmer, at the early age of seventeen he found employment in the machine shop of the Neath Iron Works, on the river of that great name, and when free from his duties in shop or foundry, spent his time in the study of the blast furnace.

Richard Parsons at that time was the owner of the historic Yniscedwyn Iron Works, and it was upon his invitation, in 1817, that young Thomas, then but twenty-three years old, took charge of these works with its coal and iron mines as general superintendent, and there he remained for twenty-three years.

In the neighborhood and underlying those works, was the only bed of anthracite coal in Great Britain, and yet the fuel used in the furnaces was coke, and had to be brought by canal from ten to fourteen miles distant.

Acting on the presumption that there was a method in the Almighty's placing there these beds of fuel, he set about to unlock Nature's secret, and to discover whether this new fuel could be applied to the smelting of iron. The first attempt met with many discouragements, the blowing power was weak, the blast was cold, and perhaps above all he was surrounded by the prejudices of the clannish Welsh furnacemen, no inconsiderable factor in those days.

News of these experiments soon reached America, where in the Lehigh and Schuylkill Valleys of Eastern Pennsylvania, vast beds of the new fuel adjacent to large deposits of hematite iron ore awaited the miner's pick.

In 1825 a furnace had been constructed at Mauch Chunk, Pennsylvania, for the purpose of experimenting with the new fuel in smelting, and as cold blast was not successful, the experiment was tried of passing the blast through a room heated with common iron stoves as hot as possible, but with equally unsatisfactory results. This furnace was then abandoned, and the owners erected another to use charcoal, thus tacitly confessing defeat, although they had not recognized in their crude practice of blast warming, that they had held a factor of development that was finally, in the hands of others, to aid in unlocking the secret.

A furnace built at Kingston, Mass., in 1827, met the same fate, as did the same year one built at Vizelle, on the borders of France and Switzerland, to utilize the anthracite of that locality.

In the meantime the spirit of the indomitable Welshman suffered no diminution of ardor, and in 1830, at Yniscedwyn, in a furnace 45 feet high and 11 feet bosh, he finally met with the greatest encouragement up to that time in the use of the new fuel, although still far from complete success.

Acting on the lines adopted by Thomas, one Frederick W. Geisenhainer, four years later, experimentally succeeded in convincing some moneyed gentlemen of that locality that following the lines of his Welsh predecessor a similar success might be made of American anthracite.

While Thomas was still working on his 45′x11′ cold-blast furnace, Neilson had installed at the Clyde Iron Works, in Scotland, his first successful hot-blast stove, and thither went Thomas to investigate, returning to Yniscedwyn with a license and drawings from Mr. Neilson, together with an expert workman to supervise the erection of the first hot-blast oven in Wales, which was soon built, and the same furnace was again blown in February 5, 1837.

Complete success replaced the discouragements of the previous years, and with Neilson's hot blast, Thomas had practically and commercially solved the problem of using anthracite in smelting pig iron.

News of the invasion of anthracite into the field hitherto occupied by coke and charcoal by the Thomas method, supplemented by hot blast spread widely, and among the visitors to Yniscedwyn that eventful year, was Solomon W. Roberts of Philadelphia, a nephew of Josiah White, a large stockholder of the Lehigh Coal and Navigation Company, whose interest lay in developing their large anthracite coal interests. Mr. Roberts was then inspecting rails at Dowlais, for a road building between White Haven and Wilkesbarre, in Pennsylvania, and the report which Mr. Roberts communicated to his uncle, resulted in the sending of Mr. Hazard, of the Navigation Company, to Wales, to investigate the practice there, and to obtain, if possible, some one who could successfully introduce the same process in America.

Mr. Hazard arrived in November, 1838, and satisfied himself that David Thomas had solved the problem that they had been forced to give up. In the meantime Thomas had removed his family to Devynock, near Castle Dhu, that his children might have the advantage of the better schools of that locality, and thither Mr. Crane, the then present owner of the Yniscedwyn Works, brought Mr. Hazard, and the result of that memorable interview was the following agreement, executed December 31, 1838.

"Memorandum of agreement made the thirty-first day of December, 1838, between Erskine Hazard for the Lehigh Crane Iron Company of the one part, and David Thomas of Castle Dhu of the other part.

1. The said Thomas agrees to remove with his family to the works to be established by the said company on or near the river Lehigh, and there to undertake the erection of a blast furnace for the smelting of iron with anthracite coal, and the working of the said furnace as furnace manager, also to give his assistance in finding mines of iron ore, fire clay, and other materials suitable for carrying on iron works, and generally to give his best knowledge and said services to the said company in the prosecution of the iron business in such manner as will best promote their interest, for the term of five years from the time of his arrival in America; provided the experiment of smelting iron with anthracite coal should be successful there.

2. The said Hazard for the said company agrees to pay the expenses of the said Thomas and his family from his present residence to the works above mentioned, on the Lehigh, and there to furnish him with a house and coal for fuel; also to pay him a salary at the rate of two hundred pounds sterling a year from the time of his stipend ceasing in his present employment until the first furnace on the Lehigh is got into blast with anthracite coal and making good iron, and after that at the rate of two hundred and fifty pounds sterling a year until a second furnace is put into operation successfully, when fifty pounds sterling shall be added to his annual salary, and so fifty pounds sterling per annum additional for each additional furnace which may be put into operation under his management.

3. It is mutually agreed between the parties that should the said Thomas fail of putting a furnace into successful operation with anthracite coal, that in that case the present agreement shall be void and the said company shall then pay the said Thomas a sum equivalent to the expense of removing himself and family from the Lehigh to their present residence.

4. In settling the salary four shilling six pence sterling are to be estimated as equal to one dollar.

In witness whereof the said parties have interchangeably set their hands and seals the date above written.

(Signed) Erskine Hazard,
For Lehigh Crane Iron Company.

Witness

(Signed) David Thomas.

(Signed) Alexander F. Hazard.

It is further mutually agreed between the Lehigh Crane Iron Company and David Thomas, the parties of the above-written agreement, that the amount of the said Thomas' salary per annum shall be ascertained by taking the United States mint price or value of the English sovereign as the value of the pound sterling instead of estimating it by the value of the dollar, as mentioned in the 4th article, and that the other remaining articles in the above-written memorandum of agreement executed by Erskine Hazard for the Lehigh Crane Iron Company and David Thomas, be hereby ratified and confirmed as they now stand written.

In witness whereof the president and secretary of the Lehigh Crane Iron Company, by order of the board of managers and the said David Thomas, have hereunto set their hands and seals, at Philadelphia, the second day of July, 1839.

In presence of
(Signed) Timothy Abbott."

(Signed) David Thomas.

Early in May the young ironmaster and his little family set sail from Swansea, bound for Liverpool, as the absence of railways at that time made coasting vessels the principal reliance.

"The steamer *Great Western* had made but two or three voyages across the Atlantic, so, after much discussion among the parties interested, it was decided that as steam was still considered a dangerous venture, we should take a sailing vessel, and our passage was engaged on the clipper ship *Roscius,* commanded by Captain Collins, cousin of E. K. Collins of the celebrated line of steamers of that name."*

* Samuel Thomas' Reminiscences of the Early Anthracite Iron Industry, A. I. M. E. Trans.

A quick voyage of twenty-three days, and New York Bay was entered, the *Roscius* debarking her passengers at New Brighton, Staten Island, and here Thomas was taken seriously ill with fever, laying helpless for a month. Recovering, preliminaries were arranged, and on July 9, 1839, the family reached Allentown, Pennsylvania, in the Lehigh Valley, four miles from the site of the new works, now called Catasauqua. Here they resided while a house was being erected for them at Catasauqua.

Many more original ideas were necessary, and had to be supplied in the erection and operation of the first furnace.† The hot-blast stoves were of the iron-pipe variety and were heated by coal burnt in a series of grates underneath, blast being introduced to facilitate combustion, in lieu of a suitable draught stack.

The hoisting apparatus for filling was termed a "water balance," and consisted of two square water-tight boxes fastened to each end of a chain, hung on a pulley, and regulated by a brake. The loaded cage was drawn up by the descent of a loaded water box, the opposite one being automatically emptied at the bottom at the completion of the previous lift, and then drawn up light to be filled in turn at the top.

The blowing engine was driven by a 12-foot breast wheel 24 feet long, taking the water from the adjacent canal under a head of 8 feet. Segments on its circumference geared into pinions at either end, from which cranks and connecting rods conveyed reciprocal motion to a walking beam, which in turn was connected to the piston of a blowing cylinder about 60 inches in diameter by 72 inches stroke.

The problem of obtaining cast-iron blowing cylinders of this size was a serious matter in these days, and before leaving England, after much trouble, they had been contracted for at the Soho works, but their transportation across the Atlantic was an unforeseen difficulty, the hatches of the existing packets being too small to admit them to the hold. After waiting some time for their arrival, application was made to the largest existing works in this country to undertake the job of making similar ones, among them the Algea of Boston, the Allaire Iron Works, and the Morgan Iron Works of New York, but they declined to undertake the work, alleging that they could not bore cylinders of that size, even if they could cast them.

The Southwark Foundry and Machine Company of Philadelphia finally undertook their manufacture, and made two cylinders, charging incidentally therefor 12½ cents per pound. To these cylinders were fitted the heads that had come from England, and the engines were ready to run, the balance being small castings, wood and strap iron. The English cylinders finally came over the following year, and formed part of two subsequent steam engines erected at the same works. These later engines are now standing idle in the blowing house of the Thomas Iron Company at its Lock Ridge Works.

July 4, 1840, celebrated not only the nation's birthday, but also the first cast of iron from furnace No. 1, the first anthracite iron successfully made in America. The blast being applied at 5 P. M. the day previous, the ore mixture being 2/3 native hematite and 1/3 magnetic from New Jersey. This furnace remained in blast until the flood of January, 1841, when the rising water put out its fires and compelled its cleaning out. During that time it had made 1,080 tons of iron, the greatest production for one week being 52 tons.

On May 18th of the same year, the furnace was again blown in, and remained in operation until August 6, 1842, making in that time 3,316 tons of pig iron.

So skeptical was the trade at the start, regarding the ability of Mr. Thomas to use anthracite coal successfully in the manufacture of pig iron, that a leading charcoal iron manufacturer gave utterance to the sarcastic declaration that he would " eat all the iron Thomas made with

† Now the Crane Iron Works of Catasauqua, Pa.

anthracite coal,'' and Mr. Thomas had the satisfaction of inviting him later to a meal of several hundred tons then on the company's banks, awaiting shipment by canal, then the only method of transportation.

A second furnace was built in 1842 and was blown in with a turbine-actuated blowing engine instead of breast-wheel and in 1843 a third furnace was started, the blowing power of which was to be furnished by steam. This departure from water power caused much concern amongst those interested, and dire prophecies were made if Thomas persisted in using this new and comparatively untried source of energy, but the Welsh ironmaster insisted, and the engine was built by the Allaire Iron Works of New York, and silenced the croakers by its successful performance. This engine had a blowing cylinder of 66″ in diameter by 72″ stroke, while the steam cylinder was 26″ in diameter with the same stroke.

The same strong hand and mind that had surmounted the discouragements attending the early manufacture of anthracite iron, now proposed to attempt its production on a larger and therefore more profitable scale, and so on Feb. 14, 1854, upon invitation, a company of eighteen well-to-do residents of Easton, Pennsylvania, and vicinity, assembled at Mrs. White's tavern in that town, and listened to this man from over sea, who had opened the eyes of the world to the possibilities heretofore latent in anthracite coal, and the formation of a new company was agreed upon with a capital of $250,000, with the following original subscribers: David Thomas and Samuel Thomas of Catasauqua, E. A. Douglass of Mauch Chunk, Chas. A. Luckenbach, Michael Krause, John P. Schall of Bethlehem, Dr. Henry Detweiler, John Drake, Derrick Hulick, Russell S. Chidsey, John T. Knight, Daniel Whitesell, Carman F. Randolph, Joseph Tuckerman and Peter S. Michler of Easton, Benjamin G. Clark of New York, and Ephraim Marsh and William H. Talcott of New Jersey.

A committee was chosen at this meeting to select an appropriate site for the location of the works of the new company, and those assembled unanimously agreed that the name of the new corporation should bear that of its projector David Thomas, and thus The Thomas Iron Company came into being.

Subsequently a Board of Directors was formed, consisting of E. A. Douglass, Wm. H. Talcott, Ephraim Marsh, Peter S. Michler, John Drake, Russell S. Chidsey and C. A. Luckenbach.

Peter S. Michler was selected as the first President, and Garman F. Randolph the first Secretary and Treasurer, while Samuel Thomas, the eldest son of David Thomas, was chosen Superintendent.

The site of the present works at Hokendauqua was selected, comprising two farms, aggregating about 185 acres, which formed the nucleus of the present works at that point, and on March 1, 1854, the construction of furnaces No. 1 and No. 2 commenced, and at the same time the town was laid out, and houses for the employees were begun.

Both these early furnaces were 60 feet high, with boshes of 18 feet, and were huge piles of masonry, being at their base 50 feet square, and constructed of limestone from the vicinity. Two beam blowing engines of about 500 horse-power each, with steam cylinders of 56 inches in diameter by 9-foot stroke, and a blowing cylinder of 90 inches diameter and same stroke, were built at the Cold Spring foundry of Robert P. Parrott, opposite West Point, New York, and were at this time the largest blowing engines ever constructed of that size. The huge arches upon which the hot blast stoves and boilers were superimposed furnished spaces underneath for the installation of these large engines, and on June 1, 1855, No. 1 furnace was put in blast, and on October 23d of the same year, furnace No. 2 was started, and were successful from the beginning. In 1861 and 1862 furnaces Nos. 3 and 4 were built. The war of the rebellion was then

occupying the greater energies of the nation, and much trouble was experienced in getting labor of various kinds.

Many of the older employees of the company had enlisted under the flag of their country. To these, however, were paid their full wages while under arms, and their old positions were ready for them at the termination of that unfortunate struggle.

For the second pair of furnaces, still larger blowing engines were constructed, having 66-inch steam and 108-inch blowing cylinders, with a stroke of 10 feet. These were made by the I. P. Morris Co., Philadelphia.

In 1867 the Lock Ridge Iron Works were purchased by the Thomas Iron Co., and added to its roll of furnaces. These works are located on the East Pennsylvania line of the Philadelphia and Reading Railroad, and has since then supplied the mills and foundries of the Central Pennsylvania district, the specialty of these works being high manganese foundry and forge irons. They became furnaces Nos. 7 and 8, the Nos. 5 and 6 being reserved for two more furnaces at Hokendauqua, which were subsequently erected in 1872 and 1873, with their necessary blowing machinery, and in April, 1882, the company added No. 9 to its collection, being the Keystone Furnace Company's plant, located on the main line of the Lehigh Valley Railroad, three miles from Easton, Pennsylvania.

In 1885 the Saucon Iron Company's furnaces were bought. This plant is on the North Pennsylvania Division of the Philadelphia and Reading Railroad, and makes a specialty of basic pig metal for open-hearth steel. They are known as Nos. 10 and 11.

In the meantime the passing years were exacting their tribute from the now venerable founder of the company, and on June 20, 1882, he passed to his long reward, ripe in years and full in honors. His oldest son Samuel had succeeded Mr. C. A. Luckenbach as the third President, and a younger son, John, had been made General Superintendent. Under this administration several large railway and mining interests were absorbed.

Upon Mr. Samuel Thomas' retirement, on September 22, 1887, B. G. Clark of New York was elected as the fourth President, and at his death, was succeeded, on October 13, 1892, by John T. Knight of Easton, Pennsylvania, for many years Secretary and Treasurer.

Mr. Knight's death shortly afterwards again made the office vacant until January 19, 1893, when B. F. Fackenthal was elected the sixth and present President of the company, David H. Thomas, grandson of "Father" Thomas, having been appointed General Superintendent, succeeding his father, who died in 1896.

Advancing years also saw the gradual remodeling of the works to suit the conditions of the times, until they stand to-day unsurpassed in their appointment for the manufacture of many grades of pig iron wholly and in part from anthracite coal.

The increasing demand for the company's product has called for increased production, which has necessitated larger furnaces, while the requirements of the foundryman, the mill owner and the steel producer, has resulted in the installation of a chemical and physical supervision of product unsurpassed in its detail.

MACHINE CAST FOUNDRY PIG IRON.*

By ALBERT LADD COLBY, Metallurgical Engineer of the Bethlehem Steel Company.

ADVANTAGES OF MACHINE CAST PIG IRON.

The advantages of machine cast pig iron to the makers of basic open hearth steel are now universally recognized. The number of basic open hearth furnaces receiving molten iron from a mixer, or direct from the blast furnace, or in some cases from a cupola, is on the increase. In cases where the iron is charged as pigs the machine cast iron is always called for, and sand cast basic iron accepted only at a reduced price. With a machine made iron there is no sand to attack the basic furnace lining. The higher proportion of combined carbon in the chilled iron makes the iron melt more rapidly, and as the combined carbon unites during melting more rapidly with oxygen than the graphite does, the bath when melted is lower in carbon than when using sand cast iron, and hence more quickly converted into steel. These advantages, in brief, mean less fuel and increased output.

In puddling furnaces, the machine cast iron is also more advantageous than the sand cast iron. The variable quantity of silica, with some little aluminia added to the bath in the form of sand adhering to the sand cast pigs, causes irregularities in the basicity of the puddling cinder, and hence irregularities in the amount of phosphorus and sulphur removed. With machine cast iron the basicity of the puddled cinder is governed more closely by the silicon in the pig iron and the silica in the "fix," causing greater uniformity in the composition of the cinder, which in turn gives more uniform product, and tends to prevent sudden and irregular cutting of the furnace linings. The increased proportion of carbon in the combined state in the machine made iron is likewise an advantage, as the puddling operation is thereby shortened without detriment to the product.

In the use of Bessemer pig iron and of low phosphorus pig iron, whether melted in the cupola for the Bessemer converter or melted in an acid open hearth furnace, the same advantages result by the use of machine cast iron as have already been outlined above.

IN THE FOUNDRY TRADE.

It is, however, the application of machine casting to foundry pig iron with which this audience is most interested. Let me first call attention to the economic advantages resulting in the use of a machine made foundry pig iron, and then speak of the difficulties attending its introduction in the foundry trade.

*Paper read before the Philadelphia Foundrymen's Association.

In purchasing a machine made foundry pig iron the customer will receive 2240 pounds per ton of iron shipped; there can be no dispute about short weights, and that abomination, the "sand ton" of 2,268 or 2,256 pounds per ton is abolished. The amount of sand adhering to iron cast in sand varies greatly. When the iron is loaded directly from the casting bed, and only has a short haul to the foundry, the sand on the pigs is excessive. If loaded from stock and hauled a considerable distance more of the sand shakes off before the pigs reach the cupola platform, but at best that remaining is a detriment, and frequent cause for dispute in weights, and an expense in melting.

In melting machine made iron the founder will find that he uses less limestone, and that, therefore, less slag is produced. This means less fuel to dissociate the carbonic acid gas in the flux, and less fuel to melt the smaller amount of slag produced; also less loss of iron in the slag. The machine cast iron also melts easier, an item which gives a further saving in fuel. The melted iron is cleaner, contains no dross and that frequent cause for defective work, "dirty iron," is absent when using a machine cast pig iron. Another advantage of machine cast iron is that the pigs of the cast are more nearly alike in chemical composition than pigs of a cast of iron run from the furnace into sand; and furthermore, that there is a greater uniformity in the different parts of a machine cast pig than in sand cast pigs. This greater regularity of the different parts of a cast is due to the fact that the furnace is tapped into 20-ton ladles, and the iron is thus mixed before casting the pigs. These are more uniform in composition, because they solidify more rapidly in the iron moulds of the casting machine, and hence there is much less time for the impurities to segregate toward the top and center of each pig.

Those interested in knowing the actual difference in composition occurring in sand cast pig iron are referred to an article written by the speaker, and published in *The Iron Age* of June 2, 1898.

FOUNDRYMENS' OBJECTIONS TO SANDLESS PIG IRON.

The speaker has met with four objections made by foundrymen to iron cast in chills, whether in the metal moulds substituted for the beds of sand in the casting house or the moulds of the casting machine.

1. The prejudice against all machine cast iron, due to the sale of some sandless misfit basic pig iron for foundry purposes.

2. The close grained fracture as compared with the fracture of sand cast iron.

3. The difficulty of drilling the pigs for analysis.

1. There is a well grounded prejudice to machine cast pig iron, owing to the sale to foundrymen of misfit basic iron cast in chills, which, although perhaps high enough in silicon, is also often high in sulphur. Doubtless in many cases this iron had not the best analysis for the purpose for which it was sold to the foundryman. It was perhaps too high in sulphur, and very likely too low in total carbon for the kind of casting into which it was made. The unsatisfactory result attending its use has given a bad name to all machine cast iron in general and has prejudiced the foundryman against its use. This is unjust to those furnaces making first-class machine cast foundry iron, but the prejudice is not to be wondered at; it can only be overcome by a straightforward explanation of the facts, and by giving a guaranteed analysis of the standard machine cast foundry pig iron offered.

2. The main stumbling block to the introduction of machine cast pig iron in the foundry is the appearance of its fracture; its looks are against it. There are two ways of meeting this objection. First, by proving to the foundryman that the machine cast iron, although having a close grained fracture, will make, if it has the right chemistry, as soft and as easily

machined a casting as an open grained sand cast pig iron of the same analysis. The close grained fracture is due to the quick cooling and to the temporary conversion of considerable of the total carbon into the combined form, with a correspondingly temporary reduction of the percentage of graphite. The change of carbon is caused by the chilling action of the iron moulds of the casting machine, and the further and deeper chill caused by the sudden cooling of the hot pig by immersion in a bath of water. This difference in the proportion of combined carbon is illustrated by the following analysis of a cast of Bethlehem iron, a portion of which was cast in sand and a portion in the casting machine:

Cast No. 7602.	Sand Cast. Per cent.	Machine Cast. Per cent.
Combined Carbon..........	.250	.920
Graphitic Carbon...........	3.210	2.460
Total Carbon..............	3.460	3.380
Silicon	3.000	2.990
Manganese	.950	.950
Phosphorus	.770	.773
Sulphur	.041	.041

The increased percentage of the combined carbon, the uniform close grain, and in some cases the increased density of the machine cast pig iron, gives higher tensile strength on specimens cut from the chilled pigs than on those cut from the sand cast pig. This increased tensile strength is misleading, for it only exists in the pig itself. When both the machine and sand cast pigs of the above cast, No. 7602, were remelted separately in a cupola, and cast into similar sized test ingots, standard test specimens threaded on each end, and of an area at point of fracture of 1 square inch, gave the following results:

Standard U. S. Army. Test specimen cut from—	Tensile strength. Pounds per square inch.
Machine Cast Pig............	41,000
Sand Cast Pig................	15,000

	Cast vertically.	Cast horizontally.
Test ingot cast from machine cast pig	17,000	17,000
Test ingot cast from sand cast pig.............	16,300	18,000

Castings made at the same time as the above test ingots from remelted sand and remelted machine cast iron were machined with equal ease, and showed similar fractures. The following analyses show that the excess of combined carbon in the machine cast pig disappeared after remelting:—*

	Carbon— Combined.	Graphitic.	Total.
Sand Cast Pig............	.250	3.210	3.460
Machine Cast Pig.........	.920	2.460	3.380
Test ingot cast by remelting sand cast pig—			
Cast Vertically...........	.368	3.022	3.390
Cast Horizontally.........	.470	2.930	3.400
Test ingot cast by remelting machine cast pig—			
Cast Vertically...........	.257	3.100	3.357
Cast Horizontally.........	.336	3.028	3.364

*For a more detailed account of this experiment see *The Iron Age* of June 20, 1901, pp. 22-23, and "Journal of American Foundrymen's Association," Vol. X, June, 1901.

Another practical illustration of the fact that the chill in the pig iron does not reappear in the casting made therefrom, if the chemistry is right, is the use of old chilled iron car wheels by foundrymen. At one time, when old car wheels were cheap, the speaker knows of an instance where 5,000 tons were purchased by a maker of cast iron pipe. The wheels showed a deep chill, but the chill did not show in the pipe. The wheel made strong pipe, but it was uniformly grey in fracture, and contained no hard or chilled spots.

The second method of meeting the objections of the appearance of the fracture of machine cast iron is to submit to the foundryman facts showing how often the appearance of the fracture of sand cast iron is misleading, and prove to him that chemistry is the only safe guide to uniform success in the foundry. How can regular results be expected in the foundry when buying pig iron by grade when the published analyses of nine different brands of, say, No. 1 Northern coke foundry iron vary as follows in silicon:—1.75, 2.00, 2.40, 2.53, 2.70, 3.00, 3.08, 3.25, and 3.44 per cent. These analyses, as well as the following, were selected from S. R. Church's book, entitled "Analyses of Pig Iron," published in May, 1900. Notice the wide variation in silicon in nineteen different brands of No. 2 Southern coke pig iron:—1.73, 1.92, 2.01, 2.14, 2.16, 2.25, 2.32, 2.40, 2.42, 2.45, 2.47, 2.50, 2.88, 2.90, 2. 92, 3.05, 3.12, 3.30 and 3.79 per cent. These variations could be proved, by further quotations, to exist in all the different grades of both Northern and Southern coke foundry pig irons.

In fact, the argument can be narrowed down to the different shipments of No. 1 iron of the same brand and from the same furnace. Let the foundryman have each car of his No. 1 iron, purchased only on grade, analyzed for silicon and sulphur for, say, two months, and the wide variations in the figures will surprise him. The converse of the above statement also holds good, for often iron of the same brand and of widely different grade, as shown by the fracture of the sand cast pigs, is exactly alike in chemical analysis. Why should a foundryman continue to purchase iron by the appearance of its fracture, when every conscientious furnaceman will admit to him that wide variations exist in the composition of the same grade of iron, and that often the foundryman pays a higher price for a No. 1 X iron than there is any necessity for?

The speaker does not mean that the foundryman can safely ignore the fracture of sand cast pig iron if he does not include the total carbon in his chemical specification, especially if he must make very soft castings, but he does mean to have it understood that if the foundryman specifies the correct silicon, sulphur and total carbon, with possibly manganese desired, that he can safely ignore the appearance of the fracture, and stoutly refuse to pay a higher price for an iron of the composition he desires, because it happens to have a No. 1 X fracture.

Among the advantages claimed for machine cast iron some have made the statement that the appearance of the fracture of machine cast iron is a safer indication of its quality than with sand cast iron. The value to the furnaceman of the chill cup test, used at some furnaces as an indication of the sulphur and silicon contents of the pig, is cited in illustration of the above statement. The speaker thinks, however, that it will be found in actual practice that the fracture of machine cast pig iron, especially from different furnaces, is an unsafe guide, and should not be depended upon by the foundryman as a substitute for the chemical analysis. To prove this opinion the speaker has taken the trouble to bring samples here to-night of the different kinds of machine cast pig iron made at Bethlehem, and desires to call particular attention to the marked influence of the presence of manganese on the appearance of the fracture of both

low phosphorus, Bessemer and high phosphorus pig irons.* The size and shape of the moulds used in different makes of casting machines, and the different methods used for cooling the hot iron by water will probably make it impossible to compare the fractures of machine cast iron from different furnaces.

3. The third objection which the speaker has heard made about machine cast iron is the difficulty in drilling the pigs for analysis. This brings up the general question of how to sample pig iron, to which important matter I will ask your attention in concluding my remarks.

SAMPLING PIG IRON FOR ANALYSIS.

With the more general incorporation of chemical specifications in contracts governing the sale of pig iron for all purposes, the question of how to determine whether the shipper has lived up to his contract becomes more important. If seller's and buyer's chemists do not agree, the first step should be an exchange of samples to check accuracy of analytical methods; in some cases the service of a reference chemist will be required. Such a test is only just when the sample drillings are ground and thoroughly mixed, and when a sufficient quantity for duplicate analysis is distributed to each chemist. Marked differences between the furnace analysis on which the casts of pig iron are selected for shipment on a certain contract, and the report of the buyer's chemist on the cars of iron received, will more often be due to improper sampling of the iron than to inaccurate analytical work. Every one knows of the unavoidable variations in the chemical composition of different parts of a cast of sand cast pig iron, or, for that matter, in different parts of a single sand cast pig. (See *The Iron Age,* June 2, 1898, pages 13-16.)

The furnaceman must consider each cast of iron as a unit, and should spare no pains or expense to obtain a sample representing the true average of the cast. He cannot honestly claim to have done this unless he has taken four, or, preferably, six samples of the molten metal during

*The exhibit created considerable interest and discussion on account of the fact that it included five kinds of pig iron—low phosphorus, bessemer, basic, mill and foundry—and in each case, when possible, as shown by the following analyses, a low and a high silicon iron had been selected. The samples were arranged in pairs, one sample showing the fracture of a low manganese iron, and the other of a high manganese iron.

LOW PHOSPHORUS.

	Per cent. No. 1.	Per cent. No. 2.	Per cent. No. 3.	Per cent. No. 4.
Silicon	.740	.770	2.020	2.070
Manganese	.350	1.730	.320	2.000
Sulphur	.016	.025	.017	.017
Phosphorus	.030	.025	.028	.027

BASIC.

	Per cent. No. 9.	Per cent. No. 10.
Silicon	.360	.350
Manganese	.840	1.860
Sulphur	.060	.053
Phosphorus	.827	.801

BESSEMER.

	Per cent. No. 5.	Per cent. No. 6.	Per cent. No. 7.	Per cent. No. 8.
Silicon	1.040	1.030	2.540	2.490
Manganese	1.120	2.550	1.300	2.200
Sulphur	.056	.049	.023	.027
Phosphorus	.061	.065	.060	.068

MILL.

	Per cent. No. 11.	Per cent. No. 12.
Silicon	1.200	1.200
Manganese	1.200	1.800
Sulphur	.035	.025
Phosphorus	.823	.770

FOUNDRY.

	Per cent. No. 13.	Per cent. No. 14.
Silicon	2.540	2.490
Manganese	.880	1.780
Sulphur	.033	.037
Phosphorus	.749	.847

casting; when the casting machine is used, the sampling can best be done as the large ladles of iron are being emptied into the moulds, by filling a small test ladle at stated intervals. If these test ladlefuls are cast into small ingots, the sample analyzed should consist of an equal quantity of drillings from each of the four or six ingots; if each small ladleful is poured into water, the same number of shot from each sample should be pounded together to make the average sample of the cast. In filling an order the furnaceman must consider each cast as a unit, and select those casts for shipment the furnace analyses of which fall within the customer's specification. As cars vary in size, and as the railroads always insist on having them loaded to nearly their full capacity, it is impossible to ship each cast of pig iron separately, for it may weigh less, but more often considerably over the capacity of the car; the best the furnaceman can do, therefore, is to load casts of similar silicon and sulphur contents on the same car.

It is obvious that the customer's chemist, when sampling the iron, must consider each carload as a unit, and from what has been said it would be manifestly unfair for him to condemn a car of iron on the analysis of drillings from only two or three pigs. A good routine method of sampling consists in selecting two pigs from the surface of the carload of iron at points equally distant from each end of the car and two more pigs from the bottom of the car, preferably at different distances from the end of the car. These pigs should be broken and drilled in the fracture, preferably by the use of a wide angle blunt pointed drill, two or three inches in diameter, using rather a slow feed, so as to obtain uniformly fine drillings. If this requires a larger drilling machine or more power than can be assigned to the task, a number of holes may be drilled in the face of each pig, using a smaller drill.

If the analysis of an equal portion of carefully mixed drillings from each of these four pigs shows a wide variation from the chemical specification under which the iron is purchased, the car of iron should not be condemned by the customer without taking a more thorough sample, consisting of a dozen, or better, twenty, pigs selected from different parts of the car. The pigs should be selected arbitrarily, and no attention paid to the fracture. With sand cast iron sold on a guarantee of 0.050 per cent, a customer could unfairly condemn many cars shipped by selecting only the pigs showing the closest grained fracture, and by taking drillings for analysis with a small drill in the top part of each pig.

SAMPLING MACHINE CAST PIG IRON.

When the iron is machine cast, the proper sampling of each car is a laborious undertaking. If low in silicon the iron is so deeply chilled that the pigs can only be drilled in the centre, if at all; the presence of 1.00 to 2.00 per cent of manganese also renders machine cast iron very hard to drill. When impossible to drill, the reduction of chips of the chilled iron to a powder in a steel mortar is a slow operation, unless the laboratory is unusually well equipped for such work. The speaker has described in *The Iron Age* of June 2, 1898, a very convenient form of steel mortar and pestle with which samples of chilled iron can be quickly pulverized.

Without for a moment denying the right of the buyer to check the furnaceman's analysis, the speaker believes that the furnaceman has a much better opportunity of determining, by conscientious sampling, the true average composition of each cast of iron, and he ventures to predict that, with the more general introduction of machine cast iron, the customer will purchase iron from furnaces where proper care is used in sampling, and then rely, with only an occasional check, on the furnace analysis of the casts loaded on each car, which information should be given on cards tacked on the inside of each car, and also by postal card advices of each day's shipment from the furnace.

This suggestion does not apply to the closer inspection necessary in some cases if the customer suspects that the furnaceman is shipping a little of his " misfit " iron on the bottom of each car of pig iron guaranteed as "standard." This dishonest practice, unfortunately carried on to some extent, is sure of detection sooner or later, and is sure to react seriously on the reputation of this furnaceman's iron in the trade.

If several cars of the same iron are to be placed in one pile, in order to equalize the difference in the chemical composition of the carloads, the first car unloaded should be distributed horizontally and evenly throughout the length of the proposed pile, the second carload similarly on top of this, and so on. Then by using vertically downward from one end of the pile, iron will be obtained which will conform very closely to the average analysis of the drillings from each car.

The greatest advantage which will result by the general introduction on the market of machine cast foundry pig iron, in the speaker's opinion, is that it will tend to hasten the day when foundry pig iron will no longer be sold by grade, based on the appearance of the fracture, but will vary in price according to its chemical analysis, which is fair alike to producer and consumer.

UNITED STATES OF AMERICA

ALABAMA.

Alabama Consolidated Coal and Iron Company, Birmingham, Jefferson County. Stacks, 2 at Ironaton, Talladega County; 1 at Gadsden, Etowah County, and 1 at Birmingham, Jefferson County. Total capacity, 150,000 tons per year. Fuel, coke. Ores, red and brown hematite. Brands, "Clifton," "Mary Pratt," and "Etowah." Product, foundry iron.

Clifton.

Average Analysis	No. 1.	No. 2.	No. 3.	No. 4.
Silicon	3.50	2.75	2.25	1.75
Phosphorus	.50	.50	.50	.50
Sulphur	.03	.03	.05	.06
Manganese	1.40	1.35	1.30	1.25
Combined Carbon	.30	.35	.40	.45
Graphitic Carbon	3.30	3.30	3.25	3.20

Note.—All sold by analysis.

Si. 3.00 and over	S. under .050
Si. 2.50 and over	S. under .050
Si. 2.00 and over	S. under .050
Si. 2.00 and under	S. under .075

Etowah.

	No. 1.	No. 2.	No. 3.	No. 4.	G. F.	Soft. No. 1.	Soft. No. 2	Silvery. No. 1	Silvery. No. 2
Silicon	2.75	2.25	2.00	1.75	1.50	3.00	3.50	5.00	6.00
Phosphorus	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sulphur	.03	.04	.04	.05	.08	.03	.04	.06	.06
Manganese	.40	.40	.40	.35	.30	.45	.45	.45	.45
Combined Carbon	.30	.40	.50	.80	1.00	.25	.25	....	....
Graphitic Carbon	3.10	3.00	2.95	2.70	2.30	3.00	2.90	2.90	2.75

Bass Foundry and Machine Company, Rock Run, Cherokee County. Rock Run Furnace. Stacks, 1. Capacity, 15,000 tons per year. Fuel, charcoal. Ore, local brown hematite. Brand, "Rock Run." Product, car wheel iron.

For analysis of this iron, see Vol. 1, p. 17.

Central Iron and Coal Company, Tuscaloosa, Tuscaloosa County. Stacks, 1. Capacity, 60,000 tons per year. Fuel, coke. Ores, brown and red. Product, foundry iron.

Furnace building, will probably be completed in 1903.

Eagle Iron Company, Attalla, Etowah County. Attalla Furnace. Stacks, 1. Capacity, 18,000 tons per year. Fuel, charcoal. Ores, red and brown. Brand, "Rome." Product, iron for car wheels, chilled rolls and strong machinery castings.

Analysis of this iron is approximately the same as that made by Rome Furnace Co., Rome, Ga.

ALABAMA (Continued)

Jenifer Furnace Company, Jenifer, Talladega County. Jenifer Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, coke. Ore, brown hematite. Brand, "Jenifer." Product, foundry iron.

	No. 1.	No. 2.	No. 3.	No. 4.
Silicon	2.500 and over	2.250–2.50	1.750–2.25	under 1.750
Phosphorus	.500–.65	.500– .65	.500– .65	.500–.650
Sulphur	under .035	under .050	under .060	.060–.100
Manganese	1.000	1.000	1.000	1.000
Combined Carbon	.500	.500	.400	
Graphitic Carbon	3.500	3.250	3.200	

Lacey-Buek Iron Company, Trussville, Jefferson County. Stacks, 1. Capacity, 50,000 tons per year. Fuel, Alabama coke. Ores, red and brown hematite. Brand, "Trussville." Product, foundry and mill irons.

For analysis of this iron, see Vol. 1, p. 21.

Northern Alabama Coal, Iron and Railway Company, Talladega, Talladega County. Talladega Furnace. Stacks, 1. Capacity, 60,000 tons per year. Fuel, coke. Ores, brown and red. Brand, "Talladega." Product, foundry and forge irons.

	No. 1 Foundry.	No. 2 Foundry.	No. 3 Foundry.	No. 4 Foundry.	Grey Forge.	No. 2 Soft.
Silicon	2.810	2.560	2.080	1.950	1.940	3.010
Phosphorus	.450	.480	.580	.530	.560	.420
Sulphur	.032	.043	.062	.053	.059	.045
Manganese	.200	.190	.230	.200	.210	.200
Combined Carbon	.210	.230	.380	.600	.740	.050
Graphitic Carbon	3.310	3.180	2.990	2.860	2.670	3.540

Republic Iron and Steel Company, Thomas. Jefferson County. Pioneer Furnaces. Stacks, 3. Total capacity, 200,000 tons per year. Fuel, Alabama coke. Ores, red and brown hematite. Brand, "Pioneer," Product, foundry iron. (Operated by Pioneer Mining and Manufacturing Company.)

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5. Silvery.
Silicon	2.500	2.200	1.980	2.250	5.50
Phosphorus	.780	.760	.760	.820	.79
Sulphur	.020	.026	.046	.050	trace
Manganese	.620	.620	.560	.590	.62
Combined Carbon	.220	.260	.420	.590	.12
Graphitic Carbon	3.410	3.270	3.000	2.980	3.40

ALABAMA (Continued)

Round Mountain Coal and Iron Company, Round Mountain, Cherokee County. Round Mountain Furnace. Stacks, 1. Capacity, 6,500 tons per annum. Fuel, charcoal (cold blast). Ore, red fossiliferous. Brand, "Round Mountain." Product, iron for car wheels and chilled rolls.

Could not obtain analysis, as furnace has been idle some time.

Shelby Iron Company, Shelby, Shelby County. Shelby Furnaces. Stacks, 2. Total capacity, 40,000 tons per year. Fuel, charcoal. Ore, brown hematite. Brand, "Shelby." Product, car wheel iron.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 5½.	No. 6.	No. 7.
Silicon	1.51	1.36	1.200	.79	.32	.31	.300	.160
Phosphorus	.40	.40	.400	.40	.39	.39	.390	.390
Sulphur	.02	.03	.037	.04	.04	.04	.046	.048
Manganese	.57	.53	.510	.50	.50	.50	.460	.450
Combined Carbon	.39	.40	.440	.46	.52	.58	.990	2.520
Graphitic Carbon	2.86	3.00	3.080	3.00	3.00	3.00	2.120	.190

Sloss-Sheffield Steel and Iron Company, Birmingham, Jefferson County, Sloss Furnaces. Stacks, 4. Total capacity, 225,000 tons per year. Fuel, coke. Ores, red fossiliferous, hard and soft, and brown hematite. Brand, "Sloss." Product, foundry and mill irons.

For analysis of this iron, see Vol. 1, p. 19.

Sloss-Sheffield Steel and Iron Company, Sheffield, Colbert County. Hattie Ensley Furnace. Stacks, 1. Capacity, 70,000 tons per year. Fuel, coke. Ore, local brown hematite. Brand, "Sheffield." Product, foundry iron.

Could not obtain analysis of this iron.

Sloss-Sheffield Steel and Iron Company, Florence, Lauderdale County. Philadelphia. Furnace. Stacks, 1. Capacity, 70,000 tons per year. Fuel, coke. Ore, brown hematite. Brand, "Florence." Product, foundry iron.

Could not obtain analysis of this iron.

ALABAMA (Continued)

Sloss-Sheffield Steel and Iron Company, Sheffield, Colbert County Lady Ensley Furnace. Stacks, 1. Capacity, 70,000 tons per year. Fuel, coke. Ore, local brown hematite. Brand, "Lady Ensley." Product, foundry and mill irons. (Operated by North Alabama Furnace Co.)

	No. 1 Foundry.	No. 2. Foundry.	No. 3. Foundry.	Grey Forge.
Silicon	3.122	3.050	3.010	2.280
Phosphorus	.583	.745	.716	.760
Sulphur	.009	.024	.024	.045
Manganese	.634	.720	.576	.691
Combined Carbon	.060	.070	.110	.240
Graphitic Carbon	3.370	3.280	3.210	3.070

Southern Mineral Land Company, Brierfield, Bibb County. Bibb Furnace. Stacks, 1. Capacity, 15,000 tons per year. Fuel, charcoal. Ore, brown hematite. Brand, "Bibb." Product, car wheel iron.

Could not obtain analysis of this iron, as furnace has been idle for some time.

Southern Car and Foundry Company, Gadsden, Etowah County. Coosa Furnaces. Stacks, 2. Total capacity, 30,000 tons per year. Fuel, charcoal. Product, car wheel and malleable irons.

Could not obtain analysis and further information as furnaces are not yet in operation.

Tennessee Coal, Iron and Railroad Company, Birmingham, Jefferson County. Alice Furnaces. Stacks, 2. Total capacity, 105,000 tons per year. Fuel, coke. Ores, red and brown. Brand, "Alice." Product, basic and foundry irons.

	Basic.
Silicon, under	1.00
Phosphorus, under	1.00
Sulphur, under	.05

For analysis of foundry iron see that made by this company at Ensley and Bessemer.

Tennessee Coal, Iron and Railroad Company, Oxmoor, Jefferson County. Oxmoor Furnaces. Stacks, 2. Total capacity 122,500 tons per year. Fuel, coke. Ores, local red. Brand, "Eureka." Product, foundry and forge irons.

	No. 2 Foundry.	No. 3 Foundry.	No. 4 Foundry.	No. 1 Soft.	No. 2 Soft.
Silicon	1.920	2.010	1.940	3.150	3.500
Phosphorus	.880	.890	.880	.860	.850
Sulphur	.035	.039	.060	.025	.016
Manganese	.450	.470	.490	.290	.340
Combined Carbon	.530	.650	.890	.200	.190
Graphitic Carbon	2.740	2.560	2.360	2.940	2.890

ALABAMA (Continued)

Tennessee Coal, Iron and Railroad Company, Sheffield, Colbert County. Sheffield Furnaces. Stacks, 3. Total capacity, 210,000 tons per year. Fuel, coke. Ores, brown hematite. Brand, "Sheffield." Product, foundry iron.

	No. 1 Foundry.	No. 2 Foundry.	No. 3 Foundry.	No. 4 Foundry.	No. 1 Soft.	No. 2 Soft.	Grey Forge.	Silvery.	Mottled.	White.
Silicon	2.590	2.520	2.600	3.550	3.500	3.200	2.160	5.400	.660	.310
Phosphorus	1.200	1.270	1.270	1.170	1.640	1.280	1.350	1.170	1.520	——
Sulphur	.026	.020	.033	.052	.026	.013	.061	.023	.114	——
Manganese	.730	.660	.630	.580	.730	.760	.490	.800	.570	——
Combined Carbon.	.220	.280	.320	.170	.150	.150	.280	.160	.800	——
Graphitic Carbon.	3.400	3.280	2.960	3.300	2.800	2.900	3.000	2.440	2.200	.130

Tennessee Coal, Iron and Railroad Company, Ensley, Jefferson County. Ensley Furnaces. Stacks, 5. Total capacity, 315,000 tons per year. Fuel, coke. Ores, red and brown. Brand, "Ensley." Product, foundry, forge and basic irons.

	No. 1 Foundry.	No. 2 Foundry.	No. 3 Foundry.	No. 4 Foundry.	Grey Forge.	No. 1 Soft.	No. 2 Soft.	Mottled.	White.	No. 1 Silver Grey.	No. 2 Silver Grey.
Silicon	2.050	1.930	1.750	1.530	1.340	3.050	3.730	1.570	.580	4.450	4.650
Phosphorus	.840	.890	.890	.880	.820	.710	.810	.920	.790	.830	.920
Sulphur	.040	.046	.050	.057	.084	.027	.025	.204	.123	.019	.015
Manganese	.370	.400	.340	.380	.240	.340	.450	.250	.140	.270	.280
Combined Carbon..	.580	.640	.610	.700	.860	.260	.050	1.840	3.250	.000	.000
Graphitic Carbon...	2.920	2.820	2.860	2.900	2.450	2.920	3.220	1.240	0.000	3.020	2.910

Tennessee Coal, Iron and Railroad Company, Bessemer, Jefferson County. Bessemer Furnaces. Stacks, 5. Total capacity, 288,000 tons per year. Fuel, coke. Ores, red and brown. Brand, "De Bardeleben." Product, foundry, forge and basic irons. Also produce spiegeleisen and ferro-manganese made from various Southern ores.

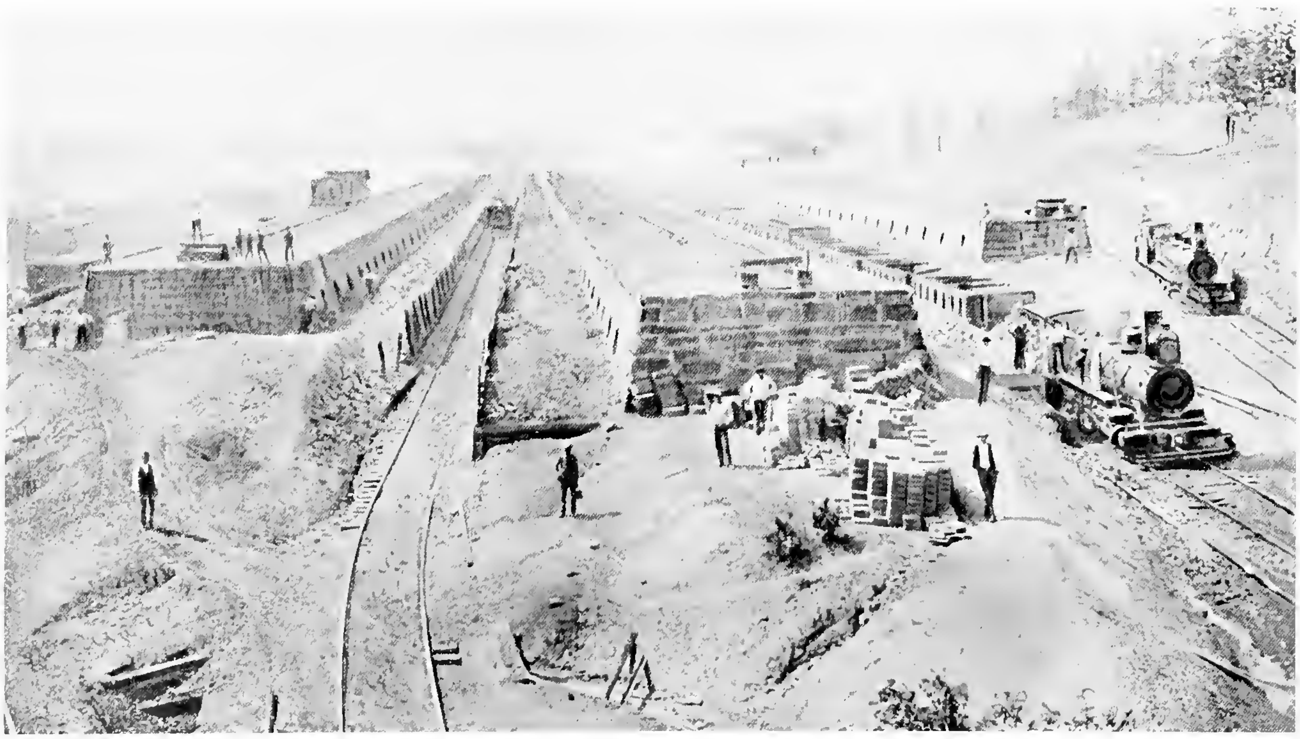
	No. 1 Foundry.	No. 2 Foundry.	No. 3 Foundry.	No. 4 Foundry.	Grey Forge.	No. 1 Soft.	No. 2 Soft.	Mottled.	White.	No. 1 Silver Grey.	No. 2 Silver Grey.
Silicon	2.660	2.890	1.540	2.710	1.490	3.830	3.830	2.050	1.120	4.660	5.140
Phosphorus	.900	.830	.900	.890	.920	.870	.940	.790	.790	.950	.960
Sulphur	.044	.040	.053	.047	.076	.029	.027	.185	.176	.016	.013
Manganese	.250	.310	.230	.220	.220	.540	.290	.210	.260	.370	.460
Combined Carbon..	.390	.180	.800	.300	.950	.130	.060	1.600	2.770	.000	.000
Graphitic Carbon...	3.240	3.010	3.710	3.030	2.420	3.170	2.890	1.600	.100	2.660	2.850

NOTE.—Basic Iron as desired made at any of the Furnaces of the Tennessee Coal, Iron and Railroad Company. They make a specialty of the production of basic iron available either for the Siemens-Martin basic open-hearth or the basic Bessemer or "Thomas" iron; in both directions the required analysis having been produced with the greatest success. In the basic open-hearth the Company guarantees its customers that the silicon and phosphorus shall each be under 1 per cent, and sulphur under .05 per cent. In the "Thomas" iron for Continental trade, a guarantee is given of phosphorus, 1.70 or above; silicon, 1.00 or below; sulphur, .05 or below; manganese, 1.00 or above. The basis iron manufactured by the Company has come to be regarded as the standard quality.

A special foundry iron is also made when required to compete with the Luxemburg iron—silicon, 2.50; phosphorus, 1.70; sulphur, .05; manganese, .95.

ALABAMA (Continued)

TENNESSEE COAL, IRON AND RAILROAD COMPANY.



COKE-OVEN PLANT, BLOCTON DIVISION, NEAR BLOCTON, BIBB COUNTY, ALA.

ERRATA.

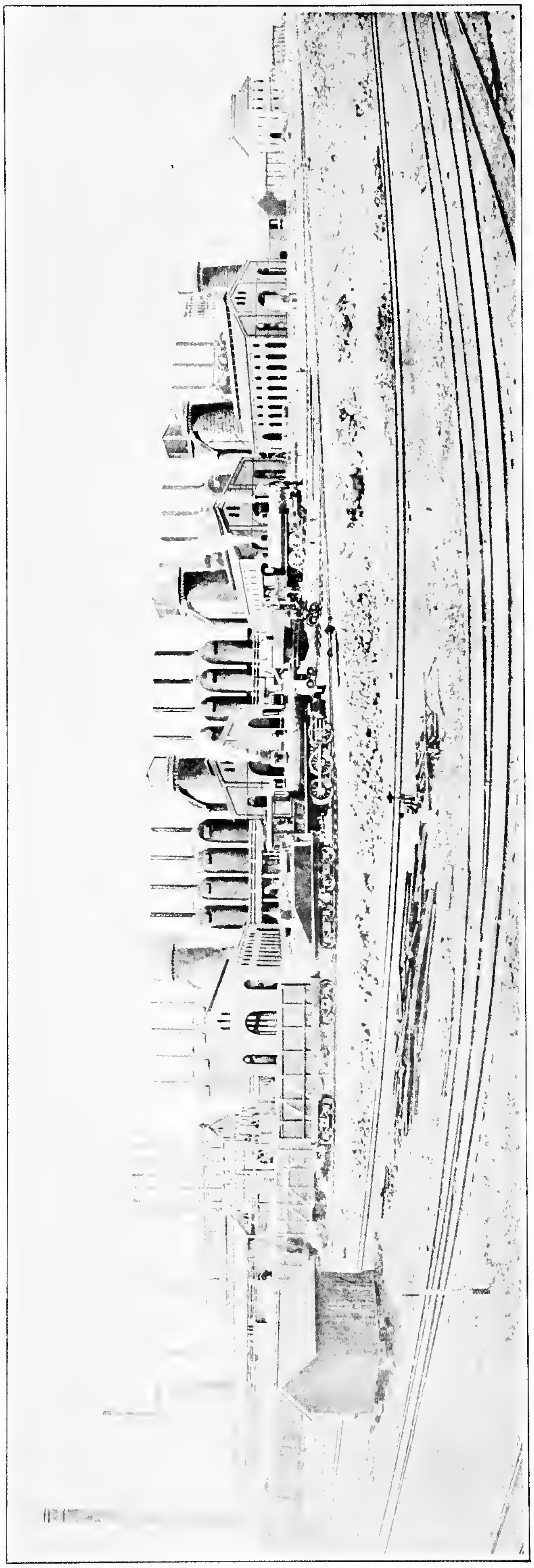
In the Note on previous page where it reads—

"The *BASIS* iron," etc.,

it should read as follows:

"The *BASIC* iron," etc.

TENNESSEE COAL, IRON AND RAILROAD COMPANY.



PANORAMA OF ENSLEY BLAST FURNACES, ENSLEY, ALA.

ALABAMA (Continued)

Tutwiler Coal, Coke and Iron Company, Birmingham, Jefferson County. Vanderbilt Furnace. Stacks, 1. Capacity, 30,000 tons per year. Fuel, coke. Ores, red limonite and brown hematite. Brand, "Vanderbilt." Product, foundry iron.

	No. 2.	No. 3.	No. 4.	G. Forge.	No. 1 Soft.	No. 2 Soft.	No. 2 C.
Silicon	2.210	2.33	2.750	2.100	2.5300	3.450	5.540
Phosphorus	.850	.85	.970	.930	.8100	.794	.860
Sulphur	.016	.02	.011	.032	.0095	.011	.013
Manganese	.804	....	....	....	.8090	....	.830
Combined Carbon	.440	.68	.400	.630	.3100	.250	.140
Graphitic Carbon	3.310	3.18	3.300	2.660	3.0300	3.610	4.300

Williamson Iron Company, Birmingham, Jefferson County. Williamson Furnace. Stacks, 1. Capacity, 18,000 tons per year. Fuel, coke. Ores, red and brown hematite. Brand, "Williamson." Product, foundry iron.

For analysis of this iron, see Vol. I, p. 18.

Woodstock Iron Works, The—Anniston, Calhoun County. Woodstock Furnaces. Stacks, 2. Total capacity, 150,000 tons per year. Fuel, Alabama coke. Ore, local brown hematite. Brand, "Woodstock." Product, foundry iron.

	No. 1 Foundry.	No. 2 Foundry.	No. 1 Soft.	No. 2 Soft.
Silicon	3.000	2.750	3.250	3.500
Phosphorus	.32 to .55	.32 to .55	.32 to .55	.32 to .55
Sulphur	.010	.015	.010	.010
Manganese	.50 to .85	.50 to .85	.50 to .85	.50 to .85

Woodward Iron Company, Woodward, Jefferson County. Stacks, 2. Total capacity, 125,000 tons per year. Fuel, coke. Ore, red fossiliferous. Brand, "Woodward." Product, foundry iron.

	No. 3 Foundry. Average Analysis
Silicon	1.250 to 1.40
Phosphorus	.790
Sulphur	.029
Manganese	.330
Combined Carbon	.710
Graphitic Carbon	2.810

COLORADO.

Colorado Fuel and Iron Company, The—Pueblo, Pueblo County. Stacks, 5. Total capacity, 600,000 tons per year. Fuel, coke. Ores, magnetite and red and brown hematite from Colorado, Wyoming and New Mexico. No brand. Product, bessemer, foundry, Scotch and mill pig irons and spiegeleisen.

CONNECTICUT.

Barnum Richardson Company, Litchfield County. Two stacks at East Canaan, 1 at Lime Rock and 1 at Sharon Valley. Total capacity, 20,000 tons per year. Fuel, charcoal. Ore, Salisbury brown hematite. Brand, "Salisbury." Product, car wheel, malleable, ordnance and machinery irons.

For analysis of this iron, see Vol. I, p. 25.

GEORGIA.

Alabama and Georgia Iron Company, Cedartown, Polk County. Stacks, 1. Capacity, 25,000 tons per year. Fuel, charcoal (only). Ores, brown hematite. Brand, "Cherokee." Product, iron for special foundry castings, mill rolls and car wheels.

Grade by Fracture.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	1.020	.860	.780	.570	.490
Phosphorus	.399	.413	.491	.482	.478
Sulphur	.020	.022	.024	.028	.039
Manganese	.600	.610	.640	.520	.580

GEORGIA (Continued)

Etna Manufacturing Company, Etna P. O., Polk County. Etna Furnace. Stacks, 1. Capacity, 10,000 tons per year. Fuel, charcoal. Ore, brown hematite. Brand, "Etna." Product, car wheel iron.

For analysis of this iron, see Vol. I, p. 27.

Georgia Iron and Coal Company, The—Rising Fawn, Dade County. Rising Fawn Furnace. Stacks, 1. Capacity, 36,000 tons per year. Fuel, coke. Ores, brown and red. Brand, "Rising Fawn." Product, foundry iron.

For analysis of this iron, see Vol. 1, p. 28.

Rome Furnace Company, The—Rome, Floyd County. Rome Furnace. Stacks, 1. Capacity, 20,000 tons per year. Fuel, charcoal. Ores, red and brown. Brand, "Rome." Product, iron for car wheels, chilled rolls and strong machinery castings.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	1.50	1.25	.80	.65	.45
Phosphorus	.40	.40	.40	.40	.40
Sulphur	trace	trace	trace	trace	trace
Manganese	.60	.60	.60	.50	.40
Combined Carbon.....	.20	.30	.37	.50	.70
Graphitic Carbon......	3.60	3.40	3.30	3.10	2.90

Southern Car Wheel Iron Company, The—Tallapoosa, Haralson County. Tallapoosa Furnace. Stacks, 1. Capacity, 15,000 tons per year. Fuel, charcoal (cold and warm blast). Ores, red and brown hematite, and gray and magnetic. Brand, "Tallapoosa." Product, car wheel and foundry irons.

Could not obtain analysis of this iron.

ILLINOIS.

Illinois Steel Company, Chicago.

Name of Works.	Location.	County.	Fuel.	Total No. of Stacks.	Annual Capacity.	Product.
North Works	Chicago	Cook	Connellsville and Pocahontas coke	2	110,000	Spiegel
South Works	S. Chicago	Cook	Connellsville and Pocahontas coke	10	1,250,000	Bessemer
Union Works	Chicago	Cook	Connellsville and Pocahontas coke	2	145,000	Bessemer
Joliet Works	Joliet	Will	Connellsville and Pocahontas coke	3	330,000	Bessemer

Ores, Gogebic Range, hematites and limonites; soft hematites, red and brown; Menominee Range, blue hematites; Marquette Range, a small portion of hard specular ores, and some few hematites. Foreign, Southern and Western for spiegeleisen and ferro-manganese. No brand.

	Bessemer.
Silicon	.750 to 1.750
Phosphorus	about .085
Sulphur	.05 and under
Manganese	.80
Combined Carbon. / Graphitic Carbon..	about 4.00

GRADES BASED ON SULPHUR ANALYSIS:

.05 and under being considered	No. 1
From this to and including .10	No. 2
From this to and including .15	No. 3
Over .15	No. 4

Iroquois Iron Company, Chicago, Cook County. Iroquois Furnaces. Stacks, 2. Total capacity, 180,000 tons per year. Fuel, coke. Ore, Northern. Brands, "Iroquois," "Sterling Scotch," "Peerless," "Mill" and "Malleable Bessemer."

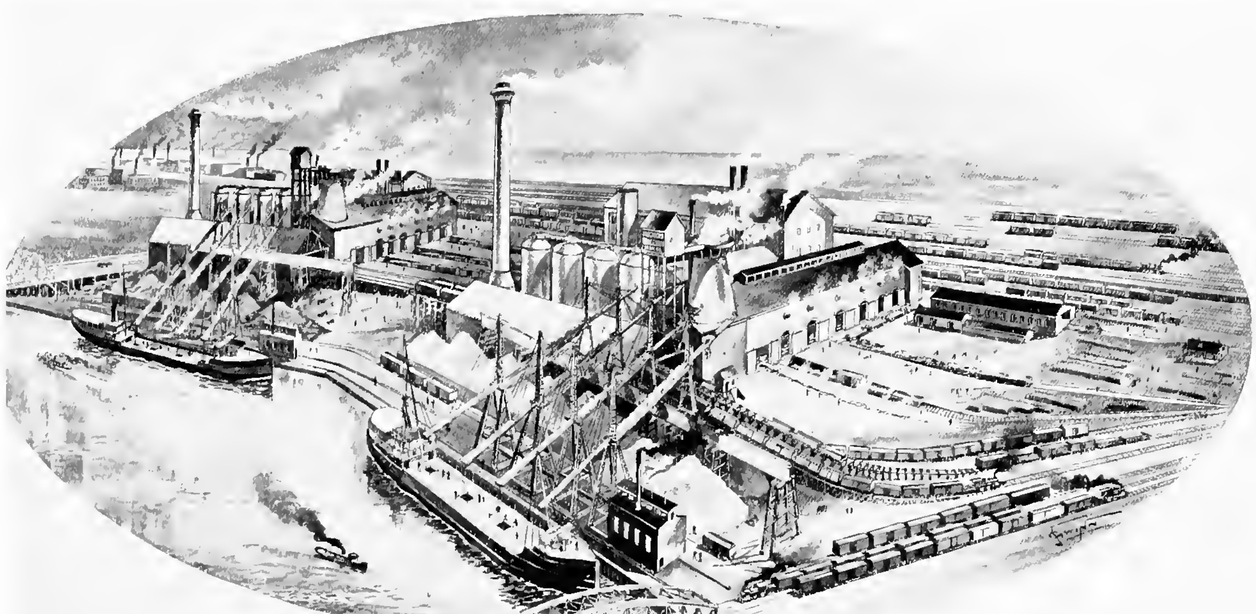
	Iroquois						
	No. 1.	No. 2	No. 3.	Sterling Scotch.	Peerless	Mill.	Malleable.
Silicon	2.25 to 2.50	1.75 to 2.25	1.35 to 1.75	2.50 to 3.00	3.00 to 3.50	———	As desired
Phosphorus	.30 to .40	.30 to .40	.30 to .40	.30 to .40	.30 to .40	.30 to .40	As desired
Sulphur	.02 to .05	.02 to .05	.02 to .06	.02 to .04	.02 to .04	.04 and up.	As desired
Manganese	.40 to .60	.40 to .60	.40 to .60	.40 to .60	.40 to .60	.40 to .60	As desired

Can also supply foundry iron of higher phosphorus if desired.

ILLINOIS (Continued)

IROQUOIS IRON COMPANY.

No. 1 IROQUOIS.



WORKS OF IROQUOIS IRON COMPANY.

ILLINOIS (Continued)

South Chicago Furnace Company, South Chicago, Cook County. Stacks, 2. Total capacity, 200,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brand. "Calumet." Product, foundry and malleable bessemer irons.

For analysis of this iron, see Vol. I, p. 28.

KENTUCKY.

Ashland Iron and Mining Company, Inc., Ashland, Boyd County. Ashland Furnaces. Stacks, 3. Total capacity, 50,000 tons per year. Fuel, raw coal and coke. Ores, Lake and native. Brand, "Ashland." Product, high silicon iron.

Average Analysis Ferrosilicon.

Ferrosilicon	10.00 to 14.00
Phosphorus	.07 to .10
Sulphur	.01 to .05
Manganese	.20 to .25
Combined Carbon	very small
Graphitic Carbon	1.75 to 2.00

Common iron graded by analysis only according to percentage of silicon required.

Hillman Land and Iron Company, Grand Rivers, Livingston County. Grand Rivers Furnaces. Stacks, 2. Total capacity, 50,000 tons per year. Fuel, coke. Ore, brown hematite. Brand, "Grand Rivers." Product, foundry and forge irons.

	No. 1.	No. 2	No. 3.	No. 4.	G. F.
Silicon	3.00	2.50	2.00	1.50	1.50
Phosphorus	.40	.40	.40	.40	.40
Sulphur	.05	.05	.06	.07	.10
Manganese	.20	.20	.20	.20	.15
Combined Carbon	.40	.50	.60	.70	1.20
Graphitic Carbon	3.20	3.10	3.00	2.95	2.40

Paducah Furnace, Paducah, McCracken County. Stacks, 1. Capacity, 23,000 tons per year. Fuel, coke. Ore, brown.

Could not obtain analysis as furnace is now out of blast.

Virginia Iron, Coal and Coke Company, Middlesborough, Bell County. Watts Furnaces. Stacks, 2. Total capacity, 75,000 tons per year. Fuel, coke. Ores, fossil and hematites. Brand, "Watts." Product, foundry and forge irons.

For analysis of this iron, see Vol. I, p. 35.

MARYLAND.

Blue Mountain Iron and Steel Company, Catoctin, Frederick County. Stacks, 1. Capacity, 35,000 tons per year. Fuel, coke. Ore, local hematite. Brand, "Catoctin." Product, foundry iron.

For analysis of this iron, see Vol. I, p. 36.

Maryland Steel Company, Sparrow's Point, Baltimore County. Stacks, 4. Total capacity, 250,000 tons per year. Fuel, coke. Ores, imported and domestic. No brand.

NOTE.—Make only Bessemer iron for own use.

The Muirkirk Furnace (Chas. E. Coffin, Prop.), Muirkirk, Prince George County. Stacks, 1. Capacity, 6,000 tons per year. Fuel, charcoal. Ores, roasted carbonate and hematite. Brand, "Muirkirk."

	No. 1.	No. 2.	No. 3.	No. 4.	No. 4¼.	No. 4½.	No. 4¾.
Silicon	2.210	1.480	1.740	1.530	1.110	.620	.730
Phosphorus	.280	.292	.293	.296	.270	.289	.281
Sulphur	.031	.044	.044	.040	.075	.056	.066
Manganese	2.220	1.740	1.810	1.500	1.230	1.080	.850
Combined Carbon	.550	.540	.430	.600	.650	.700	.410
Graphitic Carbon	3.010	3.160	2.980	2.720	2.270	2.600	2.470

Muirkirk No. 1. Open, dark colored lustrous grain, and as soft as can be made with the ores used. Especially adapted for small, light, extra strong castings. In pig bed against a chill plate does not chill. Will carry a large quantity of scrap. Tensile strength (of pig) from 20,000 to 22,000 lbs. per square inch.

Muirkirk No. 2. Open grain, with close grey spots, similar in quality to, but not as soft, and not quite so strong, as our No. 1. Does not chill in pig bed.

Muirkirk No. 3. Open grain in center, with close grain all round the outside. About same quality as No. 2. Does not chill in pig bed.

Muirkirk No. 4. Close grey grain. Does not chill in pig bed against chill plate. Tensile strength (of pig) from 24,000 to 30,000 lbs. per square inch.

Muirkirk No. 4¼. This is the strongest pig iron in the United States. Close grey grain. Chills against chill plate in pig bed from ⅛ to ¼ inch. Tensile strength (of pig) from 38,000 to 41,000 lbs. per square inch, and specially selected iron has tested as high as 52,000 lbs. per square inch. This iron mixed half and half with our No. 2, No. 3 or No. 4 irons, according to purpose and strength of mixture required, will make most satisfactory and durable castings for locomotive and engine cylinders, gun carriages, mortars, hydraulic cylinders, gear wheels, etc. For chilled rolls, car wheels, chilled plow shares, and similar uses nothing can equal "Muirkirk" iron. It is dense and free from blow-holes, and gives a hard wearing surface, yet will be found easy to machine.

MARYLAND (Continued)

THE MUIRKIRK FURNACE.

Muirkirk No. 4½. Close grey grain similar in quality to No. 4¼, but against chill plate in pig bed chills ¼ to ½ inch. Tensile strength (of pig) from 31,000 to 36,000 lbs. per square inch.

Muirkirk No. 4¾. Close grey grain similar in quality to No. 4½, but against chill plate in pig bed chills ¾ to 1 inch. Tensile strength (of pig) from 32,000 to 37,000 lbs. per square inch.

Our numbers 4½ and 4¾ are used to mix with No. 4¼ or with Nos. 1, 2, 3 or 4 to make castings of certain desired strengths, according to quality required and purpose intended.

Muirkirk No. 5 is mottled iron.

Muirkirk No. 6 is white iron.

CHARLES E. COFFIN, Proprietor Muirkirk Furnace.

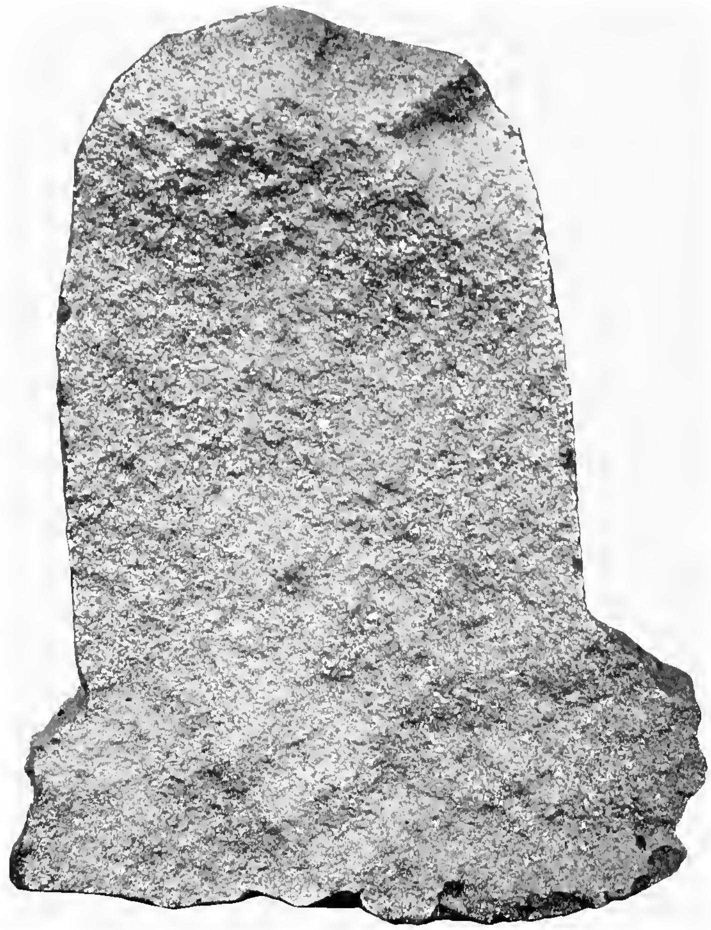
MARYLAND (Continued)

THE MUIRKIRK FURNACE.

MUIRKIRK FURNACE.

MARYLAND (Continued)

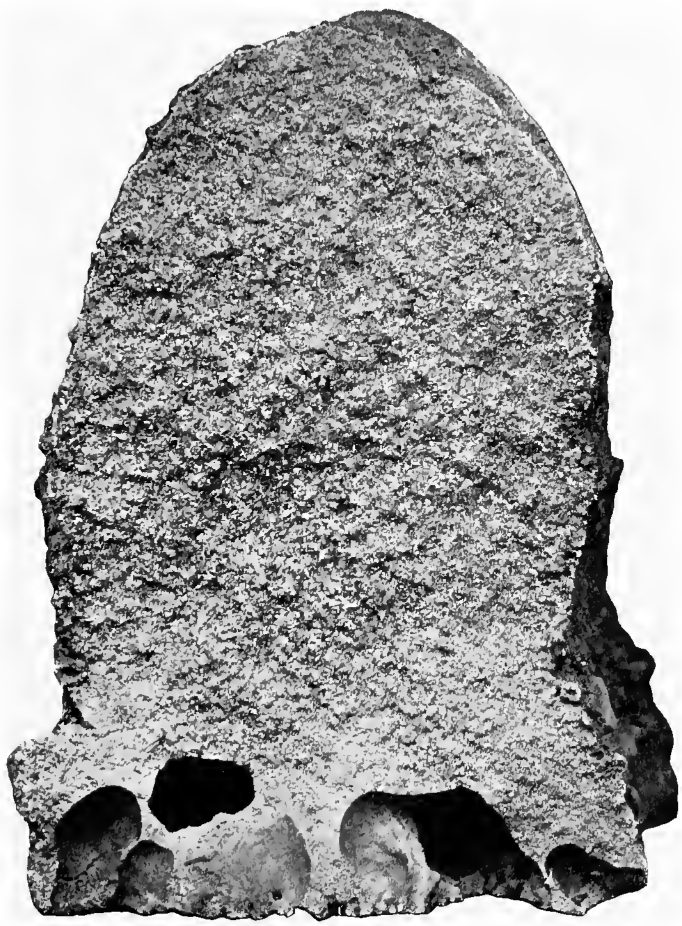
THE MUIRKIRK FURNACE.



No. 1 MUIRKIRK.

MARYLAND (Continued)

THE MUIRKIRK FURNACE.



No. 2 MUIRKIRK.

MARYLAND (Continued)

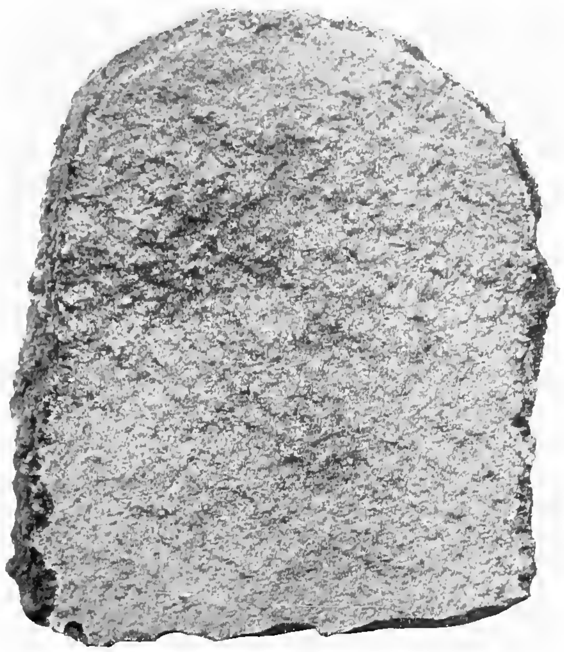
THE MUIRKIRK FURNACE.

No. 3 MUIRKIRK.

No. 4 MUIRKIRK.

MARYLAND (Continued)

THE MUIRKIRK FURNACE.



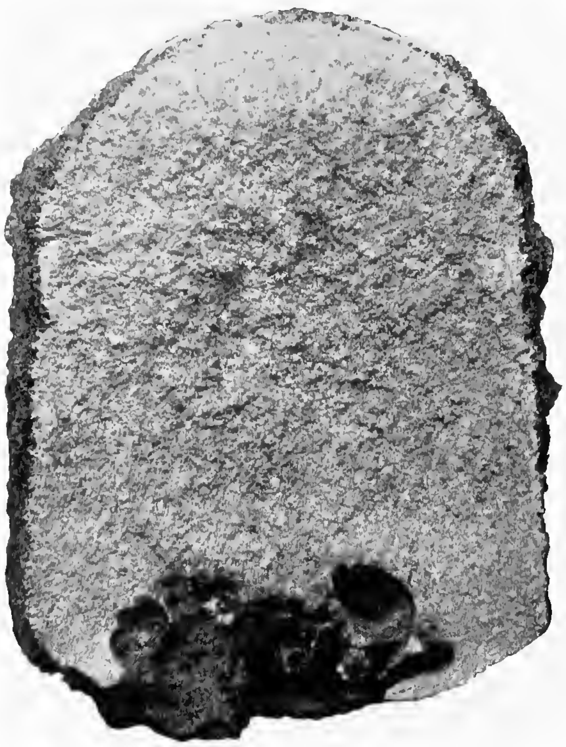
No. 4¼ MUIRKIRK.

No. 4½ MUIRKIRK.

MARYLAND (Continued)

THE MUIRKIRK FURNACE.

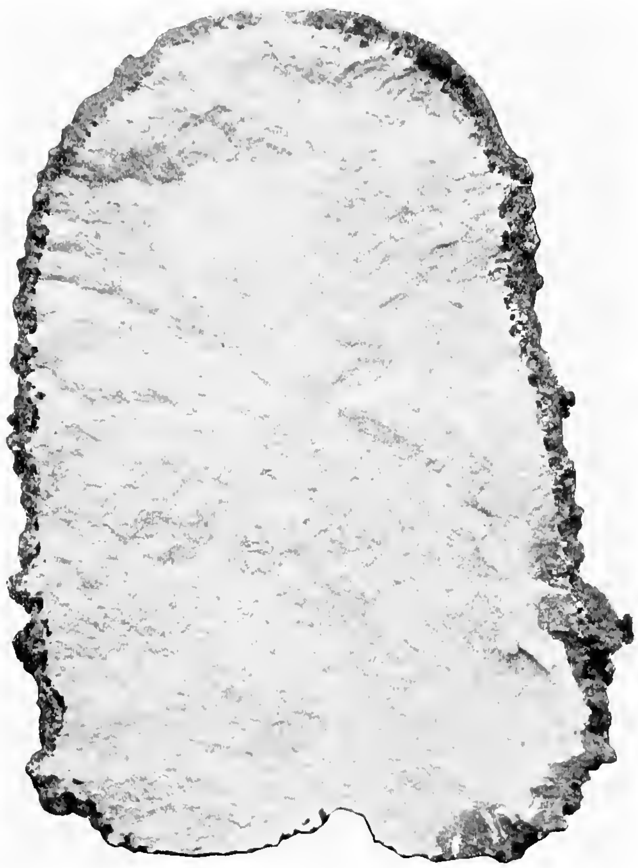
No. $4\frac{3}{4}$ MUIRKIRK.



No. 5 MUIRKIRK.

MARYLAND (Continued)

THE MUIRKIRK FURNACE.



No. 6 MUIRKIRK.

MARYLAND (Continued)

THE MUIRKIRK FURNACE.

ORE ROASTING KILNS—MUIRKIRK FURNACE.

ORE SHED—MUIRKIRK FURNACE.

MARYLAND (Continued)

THE MUIRKIRK FURNACE.

OFFICE—MUIRKIRK FURNACE.

MASSACHUSETTS.

Richmond Iron Works, Richmond Furnace P. O., Berkshire County. Stacks, 1 at Richmond, 1 at Van Deusenville and 1 at Cheshire. Total capacity, 15,000 tons per year. Fuel, charcoal. Ore, brown hematite. Brand, "Richmond." Product, foundry iron for cannon, car wheels and machinery.

For analysis of this iron, see Vol. 1, p. 36.

MICHIGAN.

Antrim Iron Company, Mancelona, Antrim County. Antrim Furnace. Stacks, 1. Capacity, 36,000 tons per year. Fuel, charcoal. Ore, hematites from Marquette District. Brand, "Antrim." Product, car wheel and malleable irons.

	A 1.	B 1.	C 1.	D 1.	S 2.	H 2.	S. 3.	H 3.	S 4.	H 4.	5.	6.
Silicon	2.00 to 2.50	1.75 to 2.00	1.50 to 1.75	1.25 to 1.50	1.00 to 1.25	.75 to 1.00	.55 to .75	.40 to .55	.30 to .40	.20 to .30	.10 to .20	.00 to .10
Phosphorus	.18 to .25	.18 to .25	.18 to .25	.18 to .25	.18 to .25	.18 to .25	.18 to .25	.18 to .25	.18 to .25	.18 to .25	.18 to .25	.18 to .25
Sulphur	nil		nil		nil		nil		nil			nil
Manganese	.45				.35		.20		.10			

For grading card of this iron, see Vol. I, p. 40.

Cleveland-Cliffs Iron Company, The—Gladstone, Delta County. Pioneer Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, charcoal. Ores, Lake Superior hard and hematite from Marquette Range. Brand, "Pioneer." Product, malleable and car wheel irons.

For grading card of this iron, see Vol. I, p. 40.

Elk Rapids Iron Company, Elk Rapids, Antrim County. Elk Rapids Furnace. Stacks, 1. Capacity, 25,000 tons per year. Fuel, charcoal. Ore, Lake Superior. Brand, "Elk Rapids." Product, car wheel and malleable irons.

For grading card, see Vol. I, p. 40.

Manistique Iron Company, Manistique, Schoolcraft County. Stacks, 1. Capacity, 40,000 tons per year. Fuel, charcoal. Ore, Lake Superior. Brand, "Champion." Product, malleable and car wheel irons.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Silicon	1.350–2.000	.850–1.350	.500– .850	.300– .500	.200– .300	.000– .200
Phosphorus	.175	.175– .210	.200	.190– .220	.180– .200	.200
Sulphur	.015– .020	.015– .020	.015– .020	.015– .020	.015– .020	.020– .025
Manganese	.300– .500	.300– .500	.300– .500	.300– .500	.300– .500	.300– .500
Combined Carbon	.350– .450	.450– .550	.550– .650	.650– .850	.850–1.300	2.500–3.000
Graphitic Carbon	3.300–3.650	3.300–3.450	3.100–3.250	3.000–3.200	2.900–3.100	....

Martel Furnace, St. Ignace, Mackinac County. Stacks, 1. Capacity, 21,000 tons per year. Fuel, charcoal. Ore, Lake Superior. Brand, "Martel."

Could not obtain analysis as furnace is now idle.

MICHIGAN (Continued)

Michigan Iron Company, Newberry, Luce County. Stacks, 1. Capacity, 27,000 tons per year. Fuel, charcoal. Ores, hard and soft Lake Superior. Brand, "Vulcan."

Out of blast since 1894.

Northern Furnace Company, Chocolay, Marquette County. Stacks, 1. Capacity, 25,000 tons per year. Fuel, charcoal. Ore, Lake Superior. Brand, "Northern."

Not in blast since 1891, and while it is expected sooner or later that furnace will resume operations, there is no immediate prospect of same.

Peninsular Iron Manufacturing Company, Ltd., Detroit, Wayne County. Peninsular Furnace. Stacks, 1. Capacity, 10,000 tons per year. Fuel, charcoal. Ore, Lake Superior. Brand, "Peninsular." Product, iron for malleable castings, chilled rolls, car wheels, cylinders and high-grade work.

For Grading Card, see Vol. I, p. 39.

Pioneer Iron Company. Stacks, 3. Excelsior Furnace at Ishpeming (now shut down), Carp River Furnace (2 stacks), at Marquette. Total capacity, 60,000 tons per year. Fuel, charcoal. Ore, Lake Superior. Brand, "Excelsior." Product, car wheel and malleable irons.

For Grading Card of this iron, see Vol. 1, p. 40.

Spring Lake Iron Company, The—Fruitport, Muskegon County. Fruitport Furnace. Stacks, 1. Capacity, 29,000 tons per year. Fuel, charcoal. Ore, Lake Superior. Brand, "Spring Lake." Product, foundry, car wheel and malleable irons.

For analysis of this iron, see Vol. I, p. 41.

Wayne Iron Company, Ltd., Detroit, Wayne County. Stacks, 1. Capacity, 18,000 tons per year. Fuel, charcoal. Ore, Lake Superior.

Could not obtain analysis of this iron as furnace has been out of blast for some time; think will resume shortly.

MINNESOTA.

Zenith Furnace Company, West Duluth, St. Louis County. West Duluth Furnace. Stacks, 1. Capacity, 80,000 tons per year. Fuel, coke. Ore, Mesabi. Brand, "Thomas." Product, bessemer, malleable and foundry irons.

For analysis of this iron, see Vol. I, p. 41.

MISSOURI.

Sligo Furnace Company, Sligo, Dent County. Sligo Furnace. Stacks, 1. Capacity, 25,000 tons per year. Fuel, charcoal. Ores, Mesabi and native Missouri Brand, "Sligo." Product, bessemer, foundry, car wheel and malleable irons.

	No. 1.
Silicon	.250
Phosphorus	.200
Sulphur	.003
Manganese	.750

St. Louis Blast Furnace Co., The—St. Louis. Missouri Furnace. Stacks, 1. Capacity, 50,000 tons per year. Fuel, Connellsville coke. Ores, Iron Mountain and West Plains, Mo. Brands, "Carondelet Scotch" and "Missouri." Product, bessemer, basic, malleable bessemer and foundry irons.

For analysis of this iron, see Vol. I, p. 42.

NEW JERSEY.

Cooper & Hewitt, Buttzville, Warren County. Pequest Furnace. Stacks, 1. Capacity, 25,000 tons per year. Fuel, anthracite coal and coke. Ores, mixture (not constant). Brand, "Pequest." Product, basic iron.

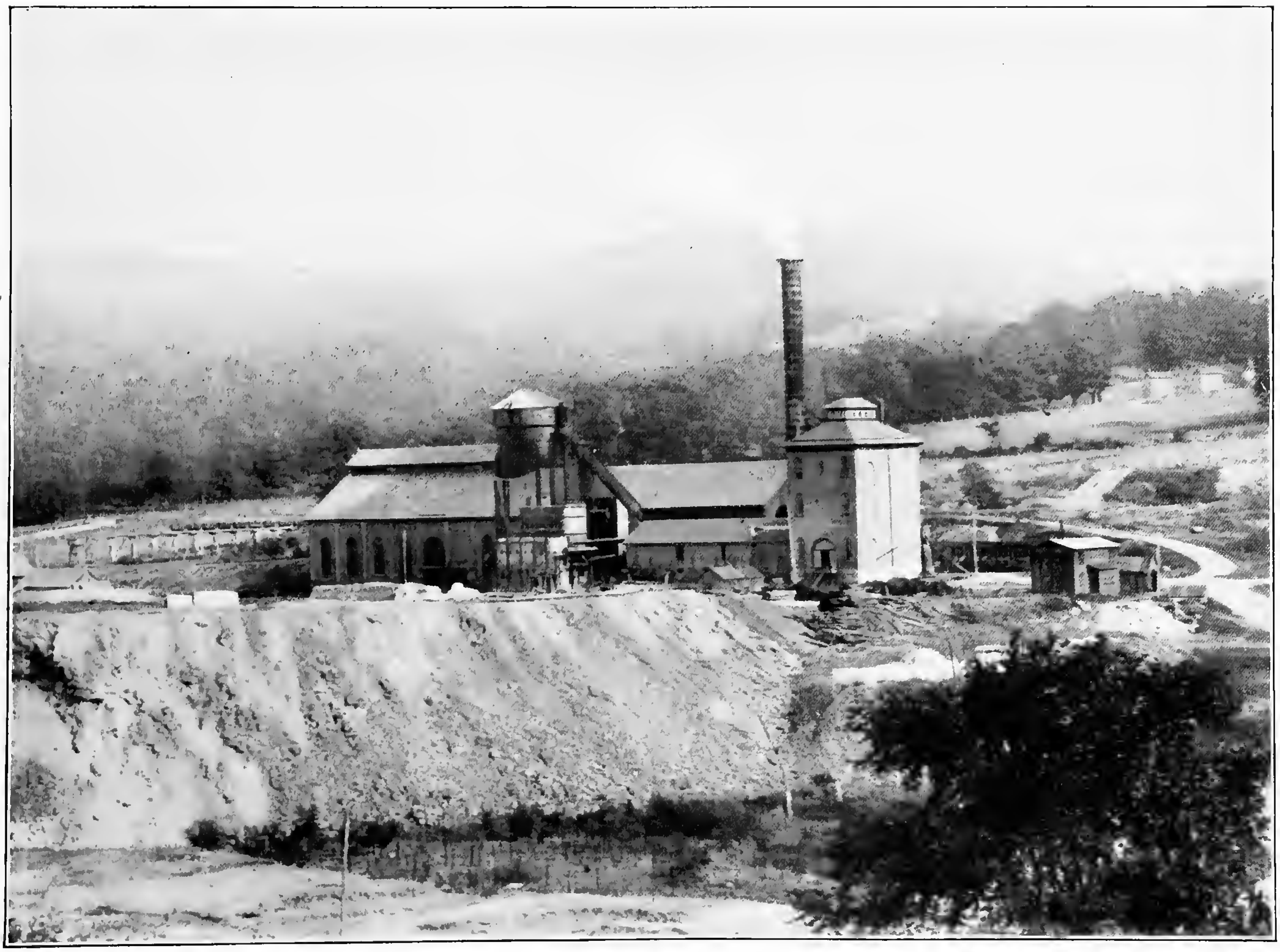
Silicon	under 1.00
Phosphorus	under 1.00
Sulphur	under .05
Manganese	about 1.50
Combined Carbon	not determined
Graphitic Carbon	not determined

NEW JERSEY (Continued)

Empire Steel and Iron Company, Oxford, Warren County. Oxford Furnace. Stacks, 1. Capacity, 30,000 tons per year. Fuel, anthracite coal and coke. Ores, Jersey magnetites and manganiferous specular hematites. Brand "Oxford."

Silicon	.500 to 1.00
Phosphorus	.600 to .80
Sulphur	.015 to .04
Manganese	.750 to 1.00

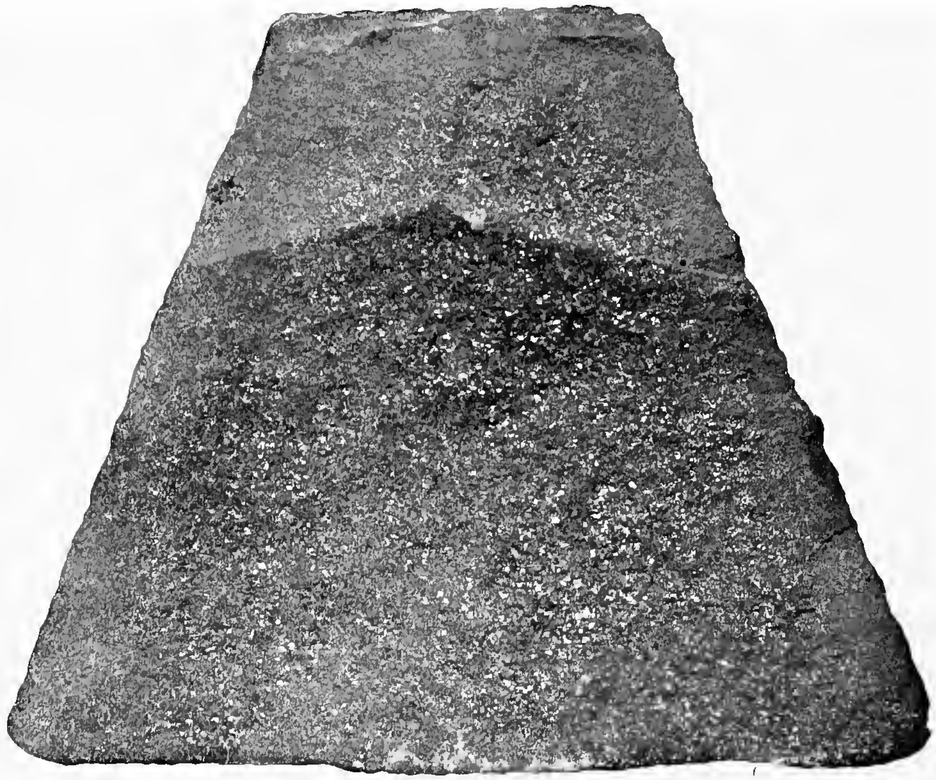
Product.—Here this Company makes a specialty of basic open hearth and grey forge.



OXFORD, N. J., FURNACE.

NEW JERSEY (Continued)

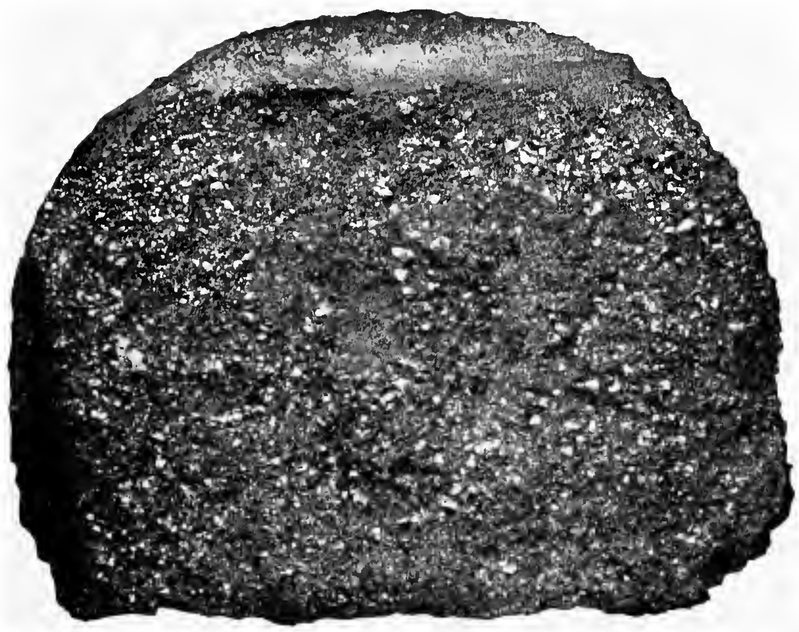
EMPIRE STEEL AND IRON COMPANY.



OXFORD BASIC.

NEW JERSEY (Continued)

EMPIRE STEEL AND IRON COMPANY.



OXFORD 2 PLAIN.

NEW JERSEY (Continued)

EMPIRE STEEL AND IRON COMPANY.

OXFORD GREY FORGE.

NEW JERSEY (Continued)

EMPIRE STEEL AND IRON COMPANY.

MOUNT HOPE, N. J., MAGNETIC ORE MINES.

NEW JERSEY (Continued)

Hackensack Meadows Company, Secaucus, Hudson County. Stacks, 1. Capacity, 27,000 tons per year. Fuel, anthracite coal. Ores, foreign hematite and New York and New Jersey magnetic. Brand, ''Secaucus.''

Could not obtain analysis of this iron as plant is out of blast.

Lackawanna Iron and Steel Company, The—Franklin Furnace P. O., Sussex County. Stacks, 1. Capacity, 55,000 tons per year. Fuel, anthracite coal and coke. Ore, Lake Superior. No brand. Product, bessemer iron.

This Company uses its whole output in own consumption.

Musconetcong Iron Works, The—Stanhope, Sussex County. Musconetcong Furnace. Stacks, 1. Capacity, 35,000 tons per year. Fuel, anthracite coal and coke. Ores, Cuban, New Jersey magnetites, Lake Superior and imported Spanish and concentrate. Brand, ''Musconetcong.''

This company makes bessemer, malleable, neutral foundry and special low phosphorus irons, but as at present time it is not definitely decided what to hold furnace to, we were unable to obtain analysis.

New Jersey Zinc Company, The—Stacks, 3. Two at Newark, Essex County, and 1 furnace in Hudson County. Total capacity, 25,000 tons per year. Fuel, anthracite coal and coke. No brand. Product, spiegeleisen.

Wharton, Jos., Phillipsburg, Warren County. Stacks, 1. Capacity, 80,000 tons per year. Fuel, anthracite coal and coke. Ores, Hibernia magnetic, 83 per cent; balance chiefly local brown hematite. Brand, ''Andover.'' Product, foundry, forge and basic open hearth.

	No. 1.	2x	2 plain.	Grey Forge.	Mottled.	White
Silicon	1.50–4.000	1.00–4.500	.750–4.500	.500–3.500	.500–1.000	.250– .500
Phosphorus	.500	.500	.500	.500	.500	.500
Sulphur	trace	trace	.025– .035	.035– .050	.050– .075	about .100
Manganese ....about	.150	.150	.150	.150	.150	.150
Combined Carbon / Graphitic Carbon	Seldom determine					

NEW JERSEY (Continued)

Wharton, Jos., Port Oram, Morris County. Wharton Furnaces. Stacks, 2, and new stack building. Total capacity present stacks, 190,000 tons per year. Fuel, one-half coal and one-half coke. Ores, 75 per cent Wharton Hibernia magnetic and 25 per cent Lake hematite. Brand, "Wharton." Product, foundry, forge and basic open hearth.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	2.750	2.400	2.00	1.50	1.00
Phosphorus	.750	.750	.75	.75	.75
Sulphur	.008	.015	.02	.03	.04
Manganese	.300	.300	.30	.30	.30
Combined Carbon....	.200	.300	.40	.50	.55
Graphitic Carbon.....	3.750	3.500	3.30	3.25	3.00

NEW YORK.

American Steel and Wire Company of New Jersey, Crown Point, Essex County. Crown Point Furnaces. Stacks, 2. Total capacity, one stack, 18,000 tons per year. Fuel, coke. Ores, Cassandra, Caucasian, Pequiry and Carribean. Product, ferromanganese.

Buffalo Union Furnace Company, The—Buffalo, Erie County. Stacks, 3,—2 coke and 1 charcoal. Capacity, coke iron, 160,000, and charcoal iron 40,000 tons per year. Ore, Lake Superior. Brands, "Buffalo" and "Buffalo Charcoal." Product, car wheel, malleable and low-phosphorus pig irons.

For analysis of this coke iron, see Vol. I, p. 45, showing that made at Buffalo Furnace, and p. 52, showing that made at Union Iron Wks.

For analysis of charcoal iron, see Vol. I, p. 45, showing that made by Buffalo Charcoal Iron Co., formerly brand "Baird."

Note.—This company also makes standard bessemer and basic irons.

Burden Iron Company, The—Troy, Rensselaer County. Stacks, 2. Total capacity, 50,000 tons per year. Fuel, anthracite coal and coke. Ores, magnetic from Northern New York; hematite and carbonate from Eastern New York, and Lake Superior. No brand.

Output is consumed entirely in own manufacture.

NEW YORK (Continued)

Chateaugay Ore and Iron Company, Standish, Clinton County. Standish Furnace. Stacks, 1. Capacity, 30,000 tons per year. Fuel, charcoal. Ore, Chateaugay. Brand "Chateaugay."

Silicon	1.28	1.000	.750	.500	.300
Phosphorus	.04	.040	.040	.040	.040
Sulphur	.01	.012	.015	.022	.025
Manganese	.05	.050	.060	.075	.080
Combined Carbon	.20	.380	.900	1.200	2.000
Graphitic Carbon	3.00	2.900	2.750	2.500	1.150

Not at present in blast.

Corrigan, McKinney & Co. Lessees—Charlotte, Monroe County. Charlotte Furnace. Stacks, 1. Capacity, 18,000 tons per year. Fuel, anthracite coal and coke. Ores, local hematite, with a mixture of Lake Champlain and Lake Superior magnetic. Brand, "Charlotte." Product, foundry iron.

For analysis of this iron, see Vol. I, p. 45.

Franklin Iron Manufacturing Company, Franklin Iron Works P. O., Oneida County. Franklin Furnace. Stacks, 1. Capacity, 30,000 tons per year. Fuel, anthracite coal and coke. Ore, fossiliferous red hematite. Brand, "Franklin." Product, foundry iron.

Could not obtain analysis of this iron.

Kirkland Furnace, Kirkland, Oneida County. Stacks, 1. Capacity, 18,000 tons per year. Fuel, anthracite coal and coke. Ores, local fossiliferous, Northern New York hematite, and Lake Champlain magnetic. Brand "Kirkland." Product, foundry iron.

For analysis of this iron, see Vol. I, p. 46.

Lackawanna Iron and Steel Company, The—West Seneca, Erie County. Stacks, 2. Fuel, coke. Now building.

NEW YORK (Continued)

Northern Iron Company, Port Henry, Essex County. Cedar Point Furnace. Stacks, 1. Capacity, 60,000 tons per year. Fuel, anthracite coal and coke. Ores, Old Bed Lake Champlain and New Bed Bessemer Lake Champlain. Brand, "Essex." Product, basic iron.

Silicon	1.00 or under
Phosphorus	1.00 or under
Sulphur	.05 or under
Manganese	.03 or under

Poughkeepsie Iron Company, Poughkeepsie, Dutchess County. Stacks, 2. Total capacity, 75,000 tons per year. Fuel, anthracite coal and coke. Ores, local brown hematite and Lake Superior hematite and magnetic. Brand, "Poughkeepsie." Product, foundry and forge irons.

Could not obtain analysis of this iron.

Salisbury Carbonate Iron Company, Columbia County. Chatham Furnace at Chatham. Stacks, 1. Capacity, 5,000 tons per year. Fuel, charcoal. Ores, Kelley, Amenia and Shaker hematites and calcined carbonate. Brands, "Salisbury" and "Carbonate." Product, iron suitable for car wheels, cannon, chilled rolls and malleable castings.

SALISBURY.

	No. 2.	No. 3.	No. 4.	No. 4½.	No. 5.
Silicon	1.843	1.290	.733	.676	.368
Phosphorus	.254	.300	.329	.225	.290
Sulphur	.049	.045	.044	.035	.042
Manganese	.400	.400	.650	.120	.160
Combined Carbon	.080	.120	.160	.900	.900
Graphitic Carbon	3.900	3.730	2.980	2.320	1.850

CARBONATE.

	No. 2.	No. 3.	No. 4.	No. 4½.	No. 5.
Silicon	1.843	1.290	.733	.676	.368
Phosphorus	.254	.300	.329	.225	.290
Sulphur	.049	.045	.044	.035	.042
Manganese	.400	.400	.650	.120	.160
Combined Carbon	.080	.120	.160	.900	.900
Graphitic Carbon	3.900	3.120	2.980	2.320	1.850

IRON GRADED FOR CAR WHEELS.

Nos. 1 and 2 (Soft and Strong), No Chill
No. 3 ....Chills ⅛ to ¼ inch
No. 4 ....Chills ¼ to ½ inch
No. 4½ ....Chills ½ to ¾ inch
No. 5 ....Chills 1¼ in. or Mottled
No. 6 ....White

IRON GRADED FOR GUN IRON CASTINGS.

No. 3 .....Chills ⅛, very strong
No. 4 .....Chills ¼, 30,000 to 32,000 lbs.
No. High 4. Chills ½, 33,000 to 35,000 lbs.
No. High 5. Chills 1, 35,000 to 38,000 lbs.
No. High 6. White

NEW YORK (Continued)

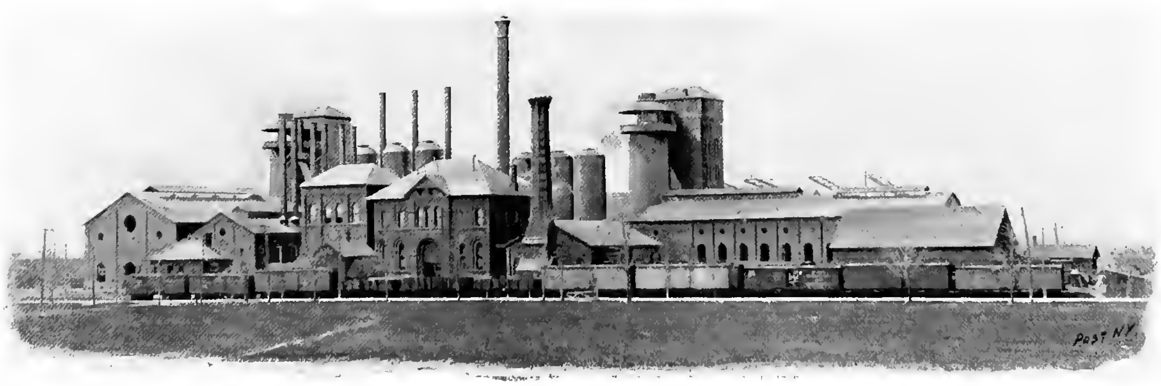
Tonawanda Iron and Steel Company, North Tonawanda, Niagara County. Niagara Furnaces. Stacks, 2. Total capacity, 162,000 tons per year. Fuel, coke. Ore, Lake Superior. Brands, "Niagara" and "Tonawanda Scotch." Product, foundry and malleable irons.

NIAGARA.

	No. 1 X.	No. 2 X.	No. 3 Foundry.	No. 2 Plain.	No. 2 Plain, Soft.	Grey Forge.
Silicon	2.500	2.40	1.75	2.00	2.90	1.50
Phosphorus	.400	.40	.40	.40	.40	.40
Sulphur	.025	.03	.05	.04	.03	.05
Manganese	.650	.65	.65	.65	.65	.65
Combined Carbon	.100	.20	.40	.35	.20	.40
Graphitic Carbon	3.600	3.50	3.20	3.30	3.60	3.25

TONAWANDA SCOTCH.

	No. 1 X.	No. 2 X.	No. 2 Plain.	Grey Forge.
Silicon	3.00	2.75	2.60	2.00
Phosphorus	.70	.70	.70	.70
Sulphur	.02	.03	.04	.05
Manganese	.75	.75	.75	.75
Combined Carbon	.10	.20	.35	.40
Graphitic Carbon	3.70	3.60	3.30	3.25



FRONT VIEW OF NIAGARA AND TONAWANDA SCOTCH FURNACES.

NEW YORK (Continued)

TONAWANDA IRON AND STEEL COMPANY.

WATERFRONT VIEW OF NIAGARA AND TONAWANDA SCOTCH FURNACES.
Showing winter's supply of 150,000 tons of Lake Superior iron ore, and one steamer from their fleet of fourteen vessels.

NEW YORK (Continued)

Troy Steel Company, The—Breaker Island, Albany County. Stacks, 3. Total capacity, 160,000 tons per year. Fuel, anthracite coal and coke. Ore, magnetic from Essex and Columbia Counties. No brand. Product, basic-bessemer pig iron entirely, used in their own consumption.

NORTH CAROLINA.

Cranberry Iron and Coal Company, Cranberry, Mitchell County. Cranberry Furnace. Stacks, 1. Capacity, 5,200 tons per year. Fuel, coke. Ore, local magnetic. Brand, "Cranberry."

Could not obtain analysis of this iron.

Empire Steel and Iron Company, Greensboro, Guilford County. Cherokee Furnace. Stacks, 1. Capacity, 35,000 tons per year. Fuel, Pocahontas coke. Ores, local magnetite and limonite. Brand, "Cherokee." Product, foundry and forge irons.

	No. 2 X
Silicon	2.630
Phosphorus	.384
Sulphur	.062

OHIO.

American Steel and Wire Company of New Jersey, Cleveland, Cuyahoga County. Stacks, 5. Total capacity, 525,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. No brand.

This company makes only one grade iron, viz., bessemer, and this for their own purposes solely.

Andrews and Hitchcock Iron Company, The—Hubbard, Trumbull County. Hubbard Furnaces. Stacks, 2. Total capacity, 150,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brand, "Hubbard Scotch" and "Climax." Product, bessemer and foundry irons.

For analysis of this iron, see Vol. I, p. 53.

Belfont Iron Works Company, Ironton, Lawrence County. Belfont Furnace. Stacks, 1. Capacity, 50,000 tons per year. Fuel, coke. Ores, Lake Superior and native. Brand, "Belfont." Product, bessemer, foundry and forge irons.

For analysis of this iron, see Vol. I, p. 53.

OHIO (Continued)

Brier Hill Iron and Coal Company, Youngstown, Mahoning County. Grace Furnace No. 2. Stacks, 1. Capacity, 100,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brand, "Brier Hill." Product, bessemer, malleable bessemer, basic and strong foundry irons.

For analysis of this iron, see Vol. I, p. 53.

Centre Furnace, Ironton, Lawrence County. Stacks, 1. Capacity, 4,500 tons per year. Fuel, charcoal. Ore, native limestone. Product, car wheel and extra strong machinery irons.

Could not obtain analysis of this iron.

Cherry Valley Iron Company, The—Leetonia, Columbiana County. Cherry Valley Furnace. Stacks, 1. Capacity, 60,000 tons per year. Fuel, coke. Ores, Lake Superior and native mixed. Brands, "Cherry Valley" and "Leetonia." Product, foundry iron.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	2.00 to 2.50	1.50 to 2.00	1.00 to 1.50	1.00 to 1.50	1.00 to 1.50
Phosphorus	.50 to .60	.50 to .60	.50 to .60	.50 to .60	.50 to .60
Sulphur	.05 and under	.05 and under	.05 and under	.05 and under	.05 and under
Manganese	.40 to .80	.40 to .80	.40 to .80	.40 to .80	.40 to .80

Clare Iron Company, Bloom Switch, Scioto County. Bloom Furnace. Stacks, 1. Capacity, 2,700 tons per year. Fuel, charcoal. Ore, hematite. Brand, , "Bloom." Product, foundry iron.

Could not obtain analysis of this iron.

Columbus Iron and Steel Company, Columbus, Franklin County. Stacks, 2. Total capacity, 175,000 tons per year. Fuel, coke. Ores, Lake Superior. Brand, "Buckeye." Product, bessemer, basic, malleable and foundry irons.

	No. 1 Foundry.	No. 2 Foundry.	No. 3 Foundry.	Malleable.	Grey Forge.	Bessemer.
Silicon	3.000	2.100	1.500	1.250	1.000	1.500
Phosphorus	.550	.550	.600	.110	.550	.091
Sulphur	.016	.018	.025	.025	.060	.020
Manganese	.500	.550	.500	.550	.500	.600
Combined Carbon.	.220	.310	.460	.450	.660	.450
Graphitic Carbon.	3.300	2.950	2.650	2.850	2.200	2.600

OHIO (Continued)

Fieser, Wagoner and Bentley, Lessees, Columbus, Franklin County. Stacks, 3 in Perry County. Total capacity, 57,000 tons per year. Fuel, coke. Ore, Lake. Brands, "Bessie" and "Hocking."

	Hocking Foundry				Bessie
	No. 1.	No. 2.	No. 3.	No. 4.	Ferro-Silicon.
Silicon	2.75	2.25	1.50	1.00	10.000 to 14.000
Phosphorus	.35	.35	.35	.35	.080
Sulphur	.02	.03	.04	.05	.010
Manganese	.40	.40	.40	.40	.400
Combined Carbon	.40	.40	.40	.40	.300
Graphitic Carbon	3.15	3.00	2.75	2.75	4.000

Girard Iron Company, Girard, Trumbull County. Mattie Furnace. Stacks, 1. Capacity, 100,000 tons per year. Fuel, coke. Ore, Lake Superior. Brand, "Girard." Product, bessemer, foundry and forge irons.

	Bessemer.	Foundry.	Grey Forge.
Silicon	1.000 to 2.000	1.750 to 2.500	1.000 to 1.750
Phosphorus	.090 to .100	.600 to .800	.450 to .800
Sulphur	.020 to .050	.030 to .040	.030 to .050
Manganese	.600 to .700	.600 to .800	.600 to 1.000
Combined Carbon	.50	.400 to .700	.600 to .800
Graphitic Carbon	3.50	3.000 to 3.700	2.750 to 3.500

Globe Iron Company, Jackson, Jackson County. Fulton Furnace. Stacks, 1. Capacity, ferro-silicon 42,000, or foundry iron 90,000 tons per year. Fuel one-half coal and one-half coke. Ore, native. Brand, "Globe."

For analysis of this iron, see Vol. I, p. 55.

Hanging Rock Iron Company, The—Hanging Rock, Lawrence County. Hamilton Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, coke. Ores, native and Lake Superior. Brand, "Hamilton." Product, foundry iron.

	No. 1.	No. 2.	No. 3.	No. 4	No. 5.
Silicon	2.100	1.810	1.120	1.260	1.490
Phosphorus	.615	.620	.650	....	....
Sulphur	.015	.020	.022	.035	.050
Manganese	.650	....	....	....	....
Combined Carbon	.380	....	....	....	....
Graphitic Carbon	3.800	....	....	....	....

NOTE.—Analyze every cast for silicon and sulphur—can vary product to suit requirements of different classes trade, sometimes making bessemer, malleable and special car wheel iron when ordered.

OHIO (Continued)

Hecla Iron and Mining Company, Hecla P. O., near Ironton, Lawrence County. Hecla Furnace. Stacks, 1. Capacity, 12,000 tons per year. Fuel, charcoal and coke. Ores, native. Brand, "Hecla." Product, iron for car wheels, chilled rolls and machinery.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	3.000	2.500	2.000	1.500	1.000
Phosphorus	.600	.700	....	....	....
Sulphur	.011	.016	.025	.032	.040
Manganese	....	....	....	....	....
Combined Carbon	....	.800	1.000	....	....
Graphitic Carbon	....	3.400	3.000	....	....

Jefferson Iron Company, Oak Hill, Jackson County. Stacks, 1. Capacity, 5,000 tons per year. Fuel, charcoal. Ore, Hanging Rock. Brand, "Anchor." Product, foundry iron.

Could not obtain analysis of this iron.

Kelly Nail and Iron Company, Ironton, Lawrence County. Sarah Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, West Virginia coke. Ore, Lake Superior. Brand, "Sarah." Product, bessemer iron.

For analysis of this iron, see Vol. I, p. 59.

La Belle Iron Works, Steubenville, Jefferson County. La Belle Furnace. Stacks, 1. Capacity, 146,000 tons per year. Fuel, coke. Ore, Lake Superior. Product, bessemer iron.

Could not obtain analysis of this iron.

Lawrence Furnace Company, The—Culbertson, Lawrence County. Lawrence Furnace. Stacks, 1. Capacity, 15,000 tons per year. Fuel, coal and coke. Ores, native and Bath County, Ky. Brands, "Lawrence" and "Pencost." Product, high silicon and strong Scotch foundry irons.

For analysis of this iron, see Vol. I, p. 56.

OHIO (Continued)

Lorain Steel Company, The—Lorain, Lorain County. Stacks, 2. Total capacity, 400,000 tons per year. Fuel, Connellsville coke. Ores, Lake Superior and Mesabi. Brand, "Lorain."

This company makes but one grade, standard bessemer, and that only for their consumption.

Marting Iron and Steel Company, The—Ironton, Lawrence County. Stacks, 2. Total capacity, 90,000 tons per year. Fuel, Pocahontas coke. Ores, Lake Superior and Kentucky. Brand, "Nellie." Product, bessemer and foundry irons.

	Bessemer.	Malleable Bessemer.	Foundry.
Silicon	3.00 and under	2.00 and under	3.00 and under
Phosphorus	.10 and under	.20 and under	.50 and under
Sulphur	.05 and under	.05 and under	.05 and under
Manganese	.50	.50	.50

McGugin Iron and Coal Company, The—Olive Furnace P. O., Lawrence County. Olive and Buckhorn Furnaces. Stacks, 2. Total capacity, 8,000 tons per year. Fuel, charcoal. Ore, native limonite. Brands, "Olive" and "Buckhorn." Product, foundry, car wheel and machinery irons.

For analysis of this iron, see Vol. I, p. 56.

National Steel Company.

Name of Works.	Location.	County.	Fuel.	No. of Stacks.	Total Annual Capacity.
Columbus	Columbus	Franklin	Coke	2	210,000
Mingo	Mingo Junction	Jefferson	Coke	3	500,000
Zanesville	Zanesville	Muskingum	Coke	1	65,000
Niles	Niles	Trumbull	Coke	1	100,000
Bellaire	Bellaire	Belmont	Coke	2	220,000
Steubenville	Steubenville	Jefferson	Coke	1	80,000
Ohio	Youngstown	Mahoning	Coke	3	600,000

Ore, Lake Superior. No special brand. Product, regular bessemer pig iron, all of which is used at their own steel works.

National Tube Company, Steubenville, Jefferson County. Steubenville Furnace. Stacks, 1. Capacity, 75,000 tons per year. Fuel, coke. Ore, Lake Superior. No brand.

	Standard Bessemer.
Silicon	1.500
Phosphorus	.085
Sulphur	.020
Manganese	.850
Combined Carbon... } Graphitic Carbon.... }	4.030

OHIO (Continued)

Ohio Iron and Steel Company, The—Lowellville, Mahoning County. Mary Furnace. Stacks, 1. Capacity, 110,000 tons per year. Fuel, coke. Ore, Lake Superior. Brands, "The Mary" and "Mary Ohio Scotch." Product, bessemer, forge, basic and foundry irons.

Analysis of Mary Ohio Scotch No. 1.

Silicon	2.800 to 3.000	Other grades similar except in the usual lower silicons, etc.
Phosphorus	.350 to .500	
Sulphur	.021 to .032	
Manganese	.780 to .620	
Combined Carbon	.410 to .530	
Graphitic Carbon	3.510 to 3.690	

In "The Mary" the phosphorus is from .20 to .225, being a stronger iron. It is also made for malleable purposes with phosphorus lower.

Penn Iron and Coal Company, The—Canal Dover, Tuscarawas County. Dover Furnace. Stacks, 1. Capacity, 150,000 tons per year. Fuel, coke. Ores, native and Lake Superior. Brands, "Tuscarawas" and "Dover." Product, bessemer, basic and foundry irons.

Now running on bessemer iron, for analysis see Vol. I, p. 58.

Republic Iron and Steel Company, Youngstown, Mahoning County. Hannah and Haselton Furnaces. Stacks, 2. Total capacity, 220,000 tons per year. Fuel, coke. Ore, Lake Superior. Brands, "Hannah" and "Haselton." Product, bessemer iron entirely.

	No. 1 Bessemer. Hannah Furnace.	Haselton Furnace.
Silicon	1.300	1.250
Phosphorus	.089	.090
Sulphur	.033	.030
Manganese	1.100	.600
Combined Carbon	.650	.500
Graphitic Carbon	3.250	3.450

River Furnace and Dock Company (Lessees), Cleveland, Cuyahoga County. River Furnace. Stacks, 1. Capacity, 72,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brands, "River," "Douglas" and "Lincoln." Product, malleable, bessemer and foundry irons.

Could not obtain analysis of this iron.

Salem Iron Company, The—Leetonia, Columbiana County. Seneca Furnace. Stacks, 1. Capacity, 90,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brands, "Seneca," "Grafton" and "Allegheny." Product, bessemer, foundry and forge irons.

For analysis of this iron, see Vol. I, p. 59.

OHIO (Continued)

Star Furnace Company, Jackson, Jackson County. Star Furnace. Stacks, 1. Capacity, 18,000 tons per year. Fuel, coke. Ore, native. Brand, "Star." Product, ferro-silicon, silvery softener and foundry irons.

For analysis of this iron, see Vol. I, p. 59.

Struthers Furnace Company, The—Struthers, Mahoning County. Anna Furnace. Stacks, 1. Capacity, 100,000 tons per year. Fuel, coke. Ore, Lake Superior. No brand. Product, basic, forge and bessemer irons.

For analysis of this iron, see Vol. I, p. 59.

Union Iron and Steel Company, Ironton, Lawrence County. Union Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, coke. Ore, Lake Superior. Brand, "Union." Product, bessemer and foundry irons.

Could not obtain analysis of this iron.

Vesuvius Charcoal Iron Company, The (Lessees)—Gray, Lawrence County. Vesuvius Furnace. Stacks, 1. Capacity, 3,000 tons per year. Fuel, charcoal (cold blast). Ore, native limestone. Brand, "Vesuvius." Product, iron for car wheels and chilled rolls.

For analysis of this iron, see Vol. I, p. 60.

Wellston Iron and Steel Company, The—Wellston, Jackson County.

WELLSTON FURNACES.

Stacks, 2. Total capacity, 30,000 tons per year. Fuel, Pocahontas coke. Ore, Lake. Brand, "Wellston W. B. C." (warm blast coke). Product, car wheel Nos. 1 to 7 and malleable irons.

	No. 1 Car Wheel.	No. 2 Car Wheel.	No. 3 Car Wheel.	No. 4 Car Wheel.	No. 5 Car Wheel.	No. 6.	No. 7.
Silicon	1.50 to 2.00	1.00 to 1.50	.75 to 1.25	.75 to 1.00	.40 to .75	.25 to .40	.05 to .20

Phosphorus	.15 to .18	
Sulphur	.01 to .09	According to silicon and grade.
Manganese	.70 to 1.25	According to specification.
Combined Carbon	.45 to .75	
Graphitic Carbon	3.00 to 3.25	

OHIO (Continued)

THE WELLSTON IRON AND STEEL COMPANY.

MADISON FURNACE.

Stacks, 1. Capacity, 5,000 tons per year. Fuel, charcoal. Ores, Hanging Rock Limestone, selected. Brand, "Madison." Product, car wheel, chill roll and cylinder irons.

Average.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	1.50	1.25	.75	.50	.35
Phosphorus	.40 to .75	.40 to .75	.40 to .75	.40 to .75	.40 to .75
Sulphur	trace	trace	trace	trace	trace
Manganese	.40 to .60	.40 to .60	.40 to .60	.40 to .60	.40 to .60

In car wheel phosporus made to suit order specification—not lower than .20 guarantee, but often runs .13.

MILTON FURNACE.

Stacks, 1. Capacity, 35,000 tons per year. Fuel, Kanawha and Pocahontas coke. Ores, non-bessemer Lake. Brands, "Wellston Foundry" for strong and most important castings, "Milton" low phosphorus.

	No. 1.	No. 2.	No. 3.	No. 4.
Silicon	1.50 to 2.00	1.25 to 1.75	1.00 to 1.75	.75 to 1.25
Phosphorus	.15 to .30	.15 to .30	.15 to .30	.15 to .30
Sulphur	trace to .05	trace to .05	trace to .05	trace to .05
Manganese	.50 to .70	.50 to .70	.50 to .70	.50 to .70

Wheeling Steel and Iron Company, Martins Ferry, Belmont County. Martins Ferry Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brand, "Martins Ferry." Product, bessemer iron.

For analysis of this iron, see Vol. I, p. 60.

Youngstown Steel Company, The—Youngstown, Mahoning County. Tod Furnace. Stacks, 1. Capacity, 90,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. No brand. Product, washed metal.

For analysis of this iron, see Vol. I, p. 60.

OREGON.

Oregon Iron and Steel Company, Oswego, Clackamas County. Oswego Furnace. Stacks, 1. Capacity, 15,000 tons per year. Fuel, charcoal. Ore, brown hematite. Brand, "Oregon." Product, foundry iron.

Could not obtain analysis of this iron, furnace shut down.

PENNSYLVANIA.

Allentown Iron Works, Allentown, Lehigh County. Stacks, 2. Total capacity, 60,000 tons per year. Fuel, anthracite coal and coke. Ores, magnetic, Lake Superior and local hematite. Brand, "Allentown." Product, foundry and low phosphorus irons.

For analysis of this iron, see Vol. I, p. 61.

Allentown Rolling Mills, The—Allentown, Lehigh County. Stacks, 2. Total capacity, 24,000 tons per year. Fuel, coal. Ores, local hematite and New Jersey and New York magnetic. Brand, "A .R. Mills." Product, foundry and forge irons.

Could not obtain analysis of this iron.

American Steel Hoop Company. Etna and Pittsburgh, Allegheny County. Isabella Furnaces. Stacks, 3. Total capacity, 500,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brand, "Isabella." Product, bessemer, foundry, mill and basic of any analysis that is specified.

For approximate analysis of this iron, see Vol. I, p. 61.

PENNSYLVANIA (Continued)

American Steel and Wire Company of New Jersey:

Edith Furnace, at Allegheny. Fuel, coke. Stacks, 2. Total annual capacity, 150,000 tons.

Shoenberger Furnaces, at Pittsburgh. Fuel, coke. Stacks, 2. Total annual capacity, 150,000 tons.

Neville Island Furnace, at Neville Island, near Pittsburgh. Fuel, coke. Stacks, 1. Annual capacity, 165,000 tons.

Ore, Lake Superior. No brand.

This company makes only one grade of iron, viz., bessemer, and this entirely for their own consumption.

Bellefonte Furnace Company, Bellefonte, Centre County. Bellefonte Furnace. Stacks, 1. Capacity, 45,000 tons per year. Fuel, coke. Ore, native hematite. Brands, "Bellefonte" and "Bellefonte-Nittany." Product, foundry, forge and malleable irons.

For analysis of this iron, see Vol. I, p. 62.

Bethlehem Steel Company, South Bethlehem, Northampton County. Bethlehem Furnaces. Stacks, 5. Total capacity, 225,000 tons per year. Fuel, anthracite coal and Connellsville coke. Ores, local and foreign hematites, magnetites and manganiferous iron ores. No brand.

	Low Phosphorus Machine Cast.	Bessemer Machine Cast.	Basic Machine Cast.	Mill Machine Cast.	Foundry Machine Cast.
Silicon	.500–2.750	.500–2.250	.500–1.250	.750–2.000	2.000–3.500
Phosphorus	.022– .035	.065– .100	.500–1.000	.500–1.000	.500–1.000
Sulphur	.010– .030	.020– .050	.020– .050	.020– .060	.010– .050
Manganese	.750–2.500	.750–2.500	.750–2.500	.750–2.500	.750–2.500
Total Carbon...	3.500–4.000	3.500–4.000	3.400–3.900	3.250–3.750	3.250–3.750

NOTE.—The ranges represent extreme variations in composition. Pig iron of any analysis, within above limits, will be furnished.

Fracture of machine-cast Pig Iron.

Fracture of sand-cast Pig Iron.

Fracture of ingot 3½ in. square and 1½ feet long cast HORIZONTALLY from machine-cast Pig.

Fracture of ingot 3½ in. square and 1½ feet long cast HORIZONTALLY from sand-cast Pig.

Fracture of ingot 3½ in. square and 1½ feet long cast VERTICALLY from machine-cast Pig.

Fracture of ingot 3½ in. square and 1½ feet long cast VERTICALLY from sand-cast Pig.

BETHLEHEM STEEL COMPANY'S FOUNDRY PIG IRON.

Cast No. 7602, one-half of which was machine-cast and the other half cast in sand.

PENNSYLVANIA (Continued)

BETHLEHEM STEEL COMPANY.

NOTE.—The cuts on previous page show clearly the fallacy of purchasing foundry pig iron by the "grade" (appearance of fracture); for as open and as easily machined a casting was made by remelting the close grained machine-cast portion of this cast, as resulted from remelting the open grained sand-cast portion of this cast.

The following analyses prove that although the combined carbon was very much higher in the machine-cast pig, so high in fact as to indicate that the iron would make *hard* castings; yet on remelting, the combined carbon in both sets of castings was entirely similar.

The foundryman can therefore safely avail himself of the advantages of cleaner and quicker melting due to the use of machine-cast foundry pig iron, which he should purchase entirely on chemical specifications.

Analysis of B. S. Co's. Foundry Pig Iron. Cast No. 7602.

	Machine Cast.	Sand Cast.
Silicon	2.990	3.000
Manganese	.950	.950
Phosphorus	.773	.770
Sulphur	.041	.041
Total Carbon	3.380	3.460
Combined Carbon	.920	.250
Graphitic Carbon	2.460	3.210
Tensile Strength lbs. per. sq. in.	41,000	15,000

Analysis of Test Ingots cast by remelting Cast No 7602.

	From Machine Cast Pig Iron. Ingot 3½″ square and 1½ feet long.		From Sand Cast Pig Iron. Ingot 3½″ square and 1½ feet long.	
	Cast Horizontally.	Cast Vertically.	Cast Horizontally.	Cast Vertically.
Silicon	2.960	2.950	2.930	2.910
Manganese	.840	.840	.840	.850
Phosphorus	.772	.764	.766	.769
Sulphur	.077	.071	.071	.064
Total Carbon	3.364	3.357	3.400	3.390
Combined Carbon	.336	.257	.470	.368
Graphitic Carbon	3.028	3.100	2.930	3.022
Tensile Strength lbs. per sq. in.	17,000	17,000	18,000	16,300

Brooke Iron Company, E. & G., The—Birdsboro, Berks County. Keystone Furnaces. Stacks, 2. Total capacity, 60,000 tons per year. Fuel, anthracite coal and coke. Ores, Lake (non-bessemer), Jersey magnetics, Cuban and nearby hematites. Brand, "Brooke." Product, basic open-hearth, foundry and forge irons.

Approx.	No. 1 X.	No. 2.	No. 3 Foundry.	Forge.	Basic.
Silicon	2.750–2.500	2.250	1.750–1.500	1.000	1.00 and less
Phosphorus	.750 or less	.750 or less	.900	1.000	1.00 and less
Sulphur	.025	.025	.050 and less	under 1.000	.05 and less
Manganese . . . . . vary	.500	.500	.500	.500	1.00–1.25
Combined Carbon . . . . widely	1.500				
Graphitic Carbon	3.500				

PENNSYLVANIA (Continued)

Cambria Steel Company, Johnstown, Cambria County. Stacks, 6. Total capacity, 650,000 tons per year. Fuel, coke. Ores, Menominee and Mesabi hematite and native and foreign manganiferous. No brand.

Could not obtain analysis of this iron, as company does not make any iron for sale.

Carbon Iron and Steel Company, Ltd., Parryville, Carbon County. Stacks, 1 (active). Capacity, 36,000 tons per year. Fuel, anthracite coal and coke. Ores, New Jersey magnetites, Pennsylvania hematites and Lake Superior. Brands, "Carbon" foundry, "Viking" low phosphorus and "Parry" bessemer.

	No. 1 Foundry.	No. 2 Foundry.	No. 3 Foundry.	Special.	Viking.	Parry.
Silicon	2.50 to 3.25	2.00 to 3.25	1.00 to 2.00	2.75 to 4.00	.75 to 2.00	.75 to 2.00
Phosphorus	.90	.90 to 1.00	1.00	.90 to 1.00	.03 and under	.08 and under
Sulphur	.03 and under	.04 and under	.05 and under	.05 and under	.03 and under	.03 and under
Manganese	.30 to .40	.30 to .40	.30 to .40	.40	.60 to .70	.50 to .70
Combined Carbon	.10 to .20	.10 to .30	.25	.10 to .30	....	....
Graphitic Carbon	3.15 to 3.50	3.00 to 3.25	2.75 to 3.00	3.00 to 3.25	....	....

Carnegie Steel Company, Allegheny County. Stacks, 19. Total capacity, 3,000,000 tons per year. Fuel, Connellsville coke. Ores, Pennsylvania, Lake Superior and foreign. No brand. Product, bessemer, basic, forge and foundry irons, spiegeleisen and ferro-manganese, mostly used in own consumption.

For analysis of some of these irons, see Vol. I, p. 64.

Central Iron and Steel Company, The—Harrisburg, Dauphin County. Paxton Furnaces. Stacks, 2. Total capacity, 100,000 tons per year. Fuel, coke. Ores, Lake. Brand, "Paxton." Product, foundry, mill, bessemer and basic open-hearth irons.

	Basic.	Malleable.
Silicon	.60 under	1.50
Phosphorus	.16 under	.15
Sulphur	.03 under	.04
Manganese	.06 under	1.00

Cherry Valley Iron Company, West Middlesex, Mercer County. Fannie Furnace. Stacks, 1. Capacity, 45,000 tons per year. Fuel, coke. Ore, Lake Superior. Brand, "Cherry Valley." Product, bessemer.

Silicon	1.700
Phosphorus	.096
Sulphur	.030
Manganese	.470

PENNSYLVANIA (Continued)

Chickies Iron Company, Ltd., The—Chickies, Lancaster County. Chickies Furnaces. Stacks, 2. Total capacity, 33,500 tons per year. Fuel, anthracite coal and coke. Ore, magnetic from Cornwall, Lebanon County. Brand, "Chickies." Product, bessemer iron.

For analysis of this iron, see Vol. I, p. 64.

Claire Furnace Company, Sharpsville, Mercer County. Claire Furnace. Stacks, 1. Capacity, 80,000 tons per year Fuel, coke. Ore, Lake Superior. No brand.

This furnace has been for some years past and is now running on standard bessemer pig iron.

Clinton Iron and Steel Company, Pittsburgh. Clinton Furnace. Stacks, 1. Capacity, 100,000 tons per year. Fuel, coke. Ore, Lake Superior. Brands, "Hector" and "Clinton." Product, foundry and bessemer irons.

For analysis of this iron, see Vol. I, p. 65.

Colonial Iron Company, Riddlesburg, Bedford County. Colonial Furnaces. Stacks, 2. Total capacity, 36,000 tons per year. Fuel, coke. Ores, Lake Superior and "Old Sterling" from New York. Brands, "Kemble," "Norway," "Keystone" and "Colonial." Product, foundry and forge irons.

For analysis of this iron, see Vol. I, p. 66.

Corrigan, McKinney and Company, Lessees. Scottdale, Westmoreland County. Charlotte Furnace. Stacks, 1. Capacity, 70,000 to 75,000 tons per year. Fuel, coke. Ore, Lake Superior. Brand, "Charlotte." Product, bessemer, mill and foundry irons.

For analysis of this iron, see Vol. I, p. 65.

Danville Bessemer Company, Danville, Montour County. Stacks, 1. Capacity, 27,000 tons per year. Fuel, anthracite coal and coke. Ores, local soft fossil; New York, New Jersey and Lake Superior hematite and magnetic and foreign. Brand, "Danville." Product, bessemer, foundry and mill irons.

Could not obtain analysis of this iron.

PENNSYLVANIA (Continued)

Dunbar Furnace Company, Dunbar, Fayette County. Dunbar Furnaces. Stacks, 2. Total capacity, 100,000 tons per year. Fuel, coke. Ores, hard and soft Lake. Brand, "Dunbar." Product, foundry, bessemer, basic, mill, car wheel and malleable irons.

	AVERAGE				
	No. 1 Foundry.	No. 2 Foundry.	No. 3 Foundry.	Mill.	Basic.
Silicon	2.00	1.70	1.25	1.00	.750
Phosphorus	.28	.28	.28	.28	.280
Sulphur	.01	.02	.03	.04	.035
Manganese	.30	.30	.30	.30	.300
Combined Carbon	.30	.40	.50	.80	.900
Graphitic Carbon	3.70	3.40	3.10	2.50	2.250

Durham Iron Company, Riegelsville, Bucks County. Stacks, 1. Capacity, 40,000 tons per year. Fuel, one-half coal and one-half coke, at present all coke. Ores, hematite, magnetic, Lake Superior and foreign. Brand, "Durham." Product, foundry iron.

	No. 1.	No. 2.	No. 3.	No. 4 Forge.
Silicon	2.50–3.00			1.00–1.75
Phosphorus	.25– .30			....
Sulphur	.01– .03	About same analysis, different		.03– .05
Manganese	.30– .40	fracture		....
Combined Carbon	....			....
Graphitic Carbon	3.00			....

Eagle Furnace Company, Roland, Centre County. Eagle Furnace. Stacks, 1. Capacity, 2,000 tons per year. Fuel, charcoal. Ore, Nittany Valley. Brand, "Curtin" Cold Blast. Product, car wheel iron.

	No. 1.
Silicon	1.25
Phosphorus	.27
Sulphur	.03
Manganese	.70
Combined Carbon	.85
Graphitic Carbon	3.30

Empire Steel and Iron Company, Catasauqua, Lehigh County. Crane Iron Works. Stacks, 4. Total capacity, 170,000 tons per year. Fuel, anthracite coal and coke. Ores, Lake Superior, New Jersey magnetites, East Pennsylvania hematites and imported Spanish low phosphorus. Brands, "Crane" and "Crane L. P." Product, foundry, low phosphorus, bessemer and basic irons.

	No. 1 X.	No. 2 X.	No. 2 Plain.	Crane Scotch.	Bessemer.	Basic.	Malleable.
Silicon	2.722	2.386	2.100	3.500	1.450	.90	1.25
Phosphorus	.793	.790	.800	.900	.019	1.00	.12
Sulphur	.015	.021	.035	.015	.015	.03	.04
Manganese	.360	.380	.380	.400	.135	.90	.50
Combined Carbon	.150	.200	.280	.100	.600	....	....
Graphitic Carbon	3.550	3.400	3.000	3.100	3.600	....	....

PENNSYLVANIA (Continued)

EMPIRE STEEL AND IRON COMPANY.

J. M. FITZGERALD, Secretary.

PENNSYLVANIA (Continued)

EMPIRE STEEL AND IRON COMPANY.

Empire Steel and Iron Company, Reading, Berks County. Henry Clay Furnaces. Stacks, 2. Total capacity, 47,450 tons per year. Fuel, anthracite coal and coke. Ore, very rich fossil. Brand, "Henry Clay." Product, foundry iron.

	No. 1. No. 2. No. 3. No. 4. No. 5. — Average —
Silicon	2.25 to 4.50
Phosphorus	2.50 to 4.00
Sulphur	.02 to .06
Manganese	1.00 to 1.25
Combined Carbon	.10 to .20
Graphitic Carbon	2.50 to 3.00

Empire Steel and Iron Company, Macungie, Lehigh County. Macungie Furnace. Stacks, 1. Capacity, 38,000 tons per year. Fuel, anthracite coal and coke. Ores, native hematites, Lake Superior and New Jersey magnetites. Brand, "Macungie." Product, bessemer, foundry and forge irons.

Analysis of this iron same as "Topton" made by this company. Occasionally this furnace is run on standard bessemer of following analysis, made largely from foreign ores that meet with a ready market in the West for the mixture with Lake ore irons.

Silicon	1.000 to 1.50
Phosphorus	.075
Sulphur	.020
Manganese	.600

Empire Steel and Iron Company, Topton, Berks County. Topton Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, anthracite coal and coke. Ores, Lake Superior, New Jersey magnetites and native hematites. Brand, "Topton." Product, foundry and forge irons.

	No. 1.	No. 2.
Silicon	2.750 to 3.000	2.000 to 2.750
Phosphorus	.700 to .800	.700 to .800
Sulphur	.015 to .025	.025 to .030
Manganese	.600	.600
Combined Carbon	.150	.250
Graphitic Carbon	3.250	3.100

The 1 and 2 X foundry irons made at this furnace have for years past been recognized as one of the leading Eastern brands, being high in silicon and low in sulphur, making it more than attractive for the manufacture of stoves and other castings requiring a fluid mixture.

At this furnace they make a specialty of basic iron analyzing under 1% in silicon, under .05% in sulphur, phosphorus .80%, manganese .50% to 1.25%, to suit the buyer.

Jersey Magnetites and East Pennsylvania Brown Hematites used at this furnace appear to be peculiarly adapted to the manufacture of strong basic pig.

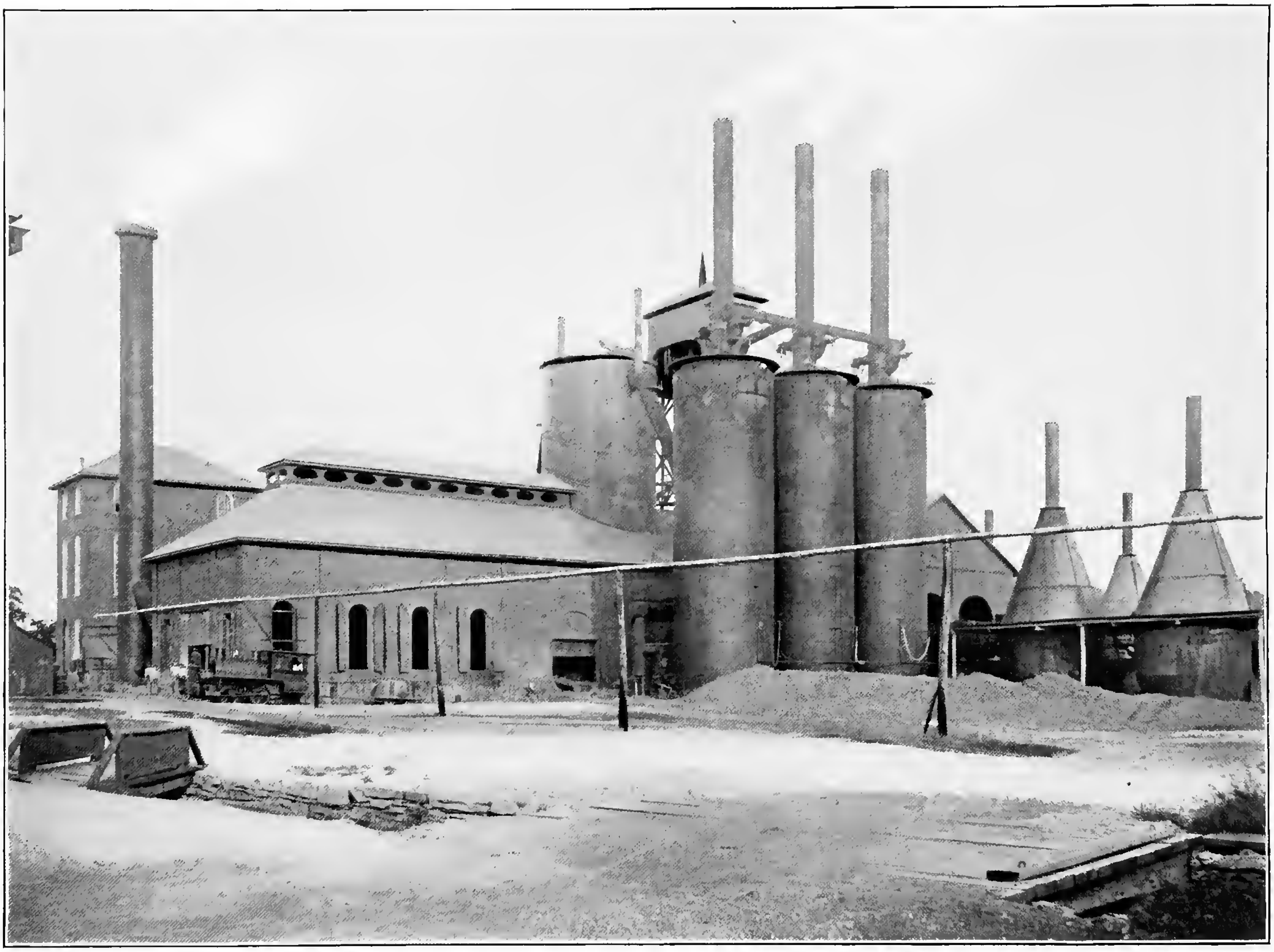
PENNSYLVANIA (Continued)

EMPIRE STEEL AND IRON COMPANY.

MACUNGIE FURNACE, MACUNGIE, PA.

PENNSYLVANIA (Continued)

EMPIRE STEEL AND IRON COMPANY.



TOPTON FURNACE, TOPTON, PA.

PENNSYLVANIA (Continued)

Emporium Iron Company (Lessee), Emporium, Cameron County. Emporium Furnace. Stacks, 1. Capacity, 50,000 tons per year. Fuel, coke. Ores, Old Sterling and Lake Superior. Brand, "Emporium." Product, foundry iron.

For analysis of this iron, see Vol. I, p. 77.

Everett Furnace, Everett, Bedford County. Stacks, 1. Capacity, 65,000 tons per year. Fuel, coke. Ores, Juniata fossil and hematite and Lake Superior hematite. Brands, "Everett Scotch," "Everett Strong Foundry," "Everett Mill," "Everett Basic" and "Everett Bessemer."

For analysis of this iron, see Vol. I, p. 77.

Glasgow Iron Company (Lessee), Pottstown, Montgomery County. Anvil Furnace. Stacks, 1. Capacity, 50,000 tons per year. Fuel, anthracite coal and coke. Ores, magnetic and hematite. Brand, "Anvil."

Not in operation for a number of years.

Glen Iron Furnace Company, The—Glen Iron, Union County. Glen Iron Furnace. Stacks, 1. Capacity, 2,000 tons per year. Fuel, charcoal (cold blast). Ores, hematite and fossil. Product, car wheel and malleable irons.

	No. 1.	No. 2.
Silicon	2.470	1.050
Phosphorus	.300	.370
Sulphur	.019	.026
Manganese	.260	.160
Combined Carbon	.370	.750
Graphitic Carbon	3.550	3.160

Heckscher and Sons Company, Richard—Swedeland, Montgomery County. Swede Furnaces. Stacks, 2. Total capacity, 125,000 tons per year. Fuel, anthracite coal and coke. Ores, Lake Superior, local and foreign. Brand, "Swede." Product, bessemer, basic, foundry and mill irons.

	No. 1 X.	No. 2 X.	Plain No. 2.	Grey Forge.	Mottled and White.	Basic.	Bessemer.
Silicon	2.500 to 3.250	2.25 to 2.50	1.90 to 2.25	.50 to 1.20	.20 to .80	1.00 and under	.75 to 2.50
Phosphorus	.600 to .800	.60 to .80	.60 to .80	.60 to .80	.60 to .80	.50 to .80	.06 to .10
Sulphur	.005 to .030	.01 to .04	.05 and under	.06 and under	.10 and under	.05 and under	.05 and under
Manganese	.500 to .700	.50 to .70	.50 to .70	.50 to .70	.50 to 1.25	.75 to 1.50	.90 to 1.25

PENNSYLVANIA (Continued)

Joanna Furnace (L. Heber Smith, Prop.), Joanna Furnace P. O., Berks County. Stacks, 1. Capacity, 2,000 tons per year. Fuel, charcoal (hot or cold blast). Ores, local magnetics and brown hematites. Brand, "Joanna." Product, car wheel iron.

	No. 1.	No. 2.	No. 3.	No. 4.
Silicon	2.00 to 2.50	1.25 to 1.50	.50 to 1.00	.20 to .50
Phosphorus	.50	.50	.50	.50
Sulphur	.02	.02	.03	.03
Manganese	.40	.60	....	....

Jones and Laughlins, Ltd., Pittsburgh. Eliza Furnaces, 4 stacks, total capacity 750,000 tons bessemer per year, and Soho Furnace, 1 stack, capacity 11,000 tons basic or 100,000 tons bessemer iron per year. Fuel, coke. Ore, Lake Superior. Brands, "Eliza" and "Soho."

Standard bessemer made at Eliza Furnaces.

Silicon	.750 to 1.150
Phosphorus	.095
Sulphur	.020 to .050
Manganese	.380

Basic (at present) made at Soho Furnace.

Silicon	.300 to 1.000
Phosphorus	up to .300
Sulphur	.010 to .050
Manganese	up to 1.300
Combined Carbon	.500 approximately
Graphitic Carbon	3.500 approximately

NOTE.—Usually standard bessemer made at Soho Furnace.

Juniata Furnace and Foundry Company, Newport, Perry County. Marshall Furnace. Stacks, 1. Capacity, 18,000 tons per year. Fuel, anthracite coal and coke. Ores, silicious native fossil and brown hematite. Brand, "Marshall." Product, foundry iron.

For analysis of this iron, see Vol. 1, p. 78.

Kittanning Iron and Steel Manufacturing Company, Kittanning, Armstrong County. Rebecca Furnace. Stacks, 1. Capacity, 70,000 tons per year. Fuel, Connellsville coke. Ores, native and Lake Superior. Brand, "Rebecca." Product, foundry and forge irons.

	No. 1.	No. 2.	No. 3.	Forge.
Silicon	2.750 to 3.500	2.500 to 3.000	2.000 to 2.500	1.500 to 2.000
Phosphorus	.300 to .700	.300 to .700	.300 to .700	.300 to .700
Sulphur	.020	.030	.045	.070
Manganese	.650 to 1.000	.650 to 1.000	.650 to 1.000	.650 to 1.000
Combined Carbon	.090 to .200	.100 to .250	.250 to .500	.300 to .600
Graphitic Carbon	3.000 to 4.000	2.750 to 3.750	1.500 to 2.750	1.500 to 2.250

PENNSYLVANIA (Continued)

Lackawanna Iron and Steel Company, The—Scranton, Lackawanna County. One stack at Scranton, Lackawanna County, five stacks at Lebanon and Cornwall, Lebanon County. Total capacity, 310,000 tons per year. Fuel, anthracite coal and coke. Ores, Cornwall and Lake Superior. Brand, "Lackawanna." Product, bessemer iron.

This company uses the whole output in their own consumption.

Leesport Furnace Company, Leesport, Berks County. Leesport Furnace. Stacks, 1. Capacity, 18,000 tons per year. Fuel, anthracite coal. Ores, local hematite and magnetic. Brand, "Leesport." Product, foundry iron.

Could not obtain analysis of this iron.

Lehigh Steel and Iron Company, Allentown, Lehigh County. Stacks, 2. Total capacity, 55,000 tons per year. Fuel, three-fourths anthracite coal and one-fourth coke. Ores, brown hematites and magnetites. Brand, "Lehigh." Product, foundry iron.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	2.500	2.250	2.000	1.750	1.500
Phosphorus	.750	.750	.750	.750	.750
Sulphur	.020	.025	.030	.035	.040
Manganese	.....	.....	.....	.....	.....
Combined Carbon	.....	.....	.....	.....	.....
Graphitic Carbon	3.500	3.400	3.250	3.100	3.000

Logan Iron and Steel Company, Greenwood Furnace P. O., Huntingdon County. Greenwood Furnace. Stacks, 1. Capacity, 3,200 tons per year. Fuel, charcoal (cold blast). Ore, local red fossiliferous. Brand, "Greenwood."

This company make five grades of Cold Blast charcoal pig iron, all of which are used in the manufacture of chilled car wheels, chilled rolls, etc., and is graded by the broken granular surface into Nos. 1, 2, 3, 4 or mottled and white iron.

McCoy and Linn, Milesburg, Centre County. Stacks, 1. Capacity, 1,800 tons per year. Fuel, charcoal (cold blast). Ore, hematite from Nittany Valley. Product, iron made specially for chilled rolls.

For analysis of this iron, see Vol. I, p. 80.

PENNSYLVANIA (Continued)

Meily, J. and R., Lebanon, Lebanon County. Lebanon Valley Furnace. Stacks, 1. Capacity, 20,000 tons per year. Fuel, anthracite coal and coke. Ore, principally Cornwall. Brand, "Lebanon Valley."

For analysis of this iron, see Vol. I, p. 79.

Mont Alto Iron Company, Mont Alto, Franklin County. Mont Alto Furnace. Stacks, 1. Capacity, 10,000 tons per year. Fuel, charcoal (cold and warm blast). Ore, brown hematite. Brand, "Mont Alto." Product, iron for car wheels, chilled rolls, cylinders, guns and forge and foundry purposes. Grade from No. 1 to No. 6,—No. 1 being foundry grey iron, and No. 6 being white iron. Our No. 3 is subgraded into Nos. $3\frac{1}{8}$, $3\frac{2}{8}$, $3\frac{4}{8}$, $3\frac{6}{8}$, and $3\frac{8}{8}$. The fraction indicates depth of chill. Thus, No. $3\frac{2}{8}$ chills $\frac{1}{4}$ inch deep, and No. $3\frac{8}{8}$ chills 1 inch.

Could not obtain analysis of this iron, as furnace has been idle for some nine years.

National Tube Company, McKeesport, Allegheny County. Monongahela Furnaces. Stacks, 2. Total capacity, 275,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. No brand.

	Standard Bessemer.
Silicon	1.500
Phosphorus	.085
Sulphur	.020
Manganese	.850
Combined Carbon / Graphitic Carbon	4.030

National Steel Company, Sharon Works, Sharon, Mercer County. Stacks, 2. Total capacity, 82,125 tons per year. Fuel, Connellsville coke. Ore, Lake Superior soft. No brand. Product, basic open hearth iron.

	Basic.
Silicon	.950
Phosphorus	.297
Sulphur	.018
Manganese	1.060

National Steel Company, Newcastle Works, Newcastle, Lawrence County. Stacks, 4. Total capacity, 580,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. No brand. Product, bessemer iron.

Product of National Steel Company used entirely at their own works.

PENNSYLVANIA (Continued)

New Jersey Zinc Company, South Bethlehem, Northampton County. Stacks, 1. Capacity, 5,400 tons per year. Fuel, anthracite coal and coke. Product, spiegeleisen from zinc residuum.

Northside Iron Company, Sharpsville, Mercer County. Stacks, 1. Capacity, 18,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Product, standard bessemer iron.

NOTE.—As yet furnace has made no foundry iron.

Pennsylvania Steel Company, The—Steelton, Dauphin County. Four stacks at Steelton, 1 at Harrisburg, Dauphin County, and 2 at Lebanon, Lebanon County. Total capacity, 430,000 tons per year. Fuel, anthracite coal and coke. Ores, imported and domestic. No brand.

Make iron for own use entirely.

Pennsylvania Furnace Company, Sheridan, Lebanon County. Sheridan Furnaces. Stacks, 2. Total capacity, 60,000 tons per year. Fuel, anthracite coal and coke. Ores, Cornwall and Lake Superior. Brands, "Sheridan" and "Vulcan." Product, foundry, forge and bessemer irons.

For analysis of this iron, see Vol. I, p. 81.

Perkins and Company, Limited, Sharpsville, Mercer County. Mabel Furnace. Stacks, 1. Capacity, 70,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brand, "Mabel."

NOTE.—This furnace makes an extra strong and tough foundry iron analyzing about 1.50 silicon and .18 phosphorus. Also makes an iron similar to this in analysis used largely for malleable purposes; standard bessemer also made.

Pickands, Mather and Company, Alice Furnace at Sharpsville and Ella Furnace at West Middlesex. Stacks, 2. Total capacity, 156,000 tons per year. Fuel, coke. Ore, Lake Superior. Brands, "Alice" and "Ella." Product, bessemer and foundry irons.

For analysis of this iron, see Vol. I, p. 81.

PENNSYLVANIA (Continued)

Pilling and Crane, Pottsville, Schuylkill County. Pioneer Furnaces. Stacks, 2. Total capacity, 40,000 tons per year. Fuel, anthracite coal. Ores, foreign, Lake Superior and New Jersey magnetic. Brand, "Pioneer." Product, bessemer and mill irons.

Could not obtain analysis of this iron, as furnaces have been idle since 1893.

Potts, William M., Wyebrooke, Chester County. Isabella Furnace. Stacks, 1. Capacity, 5,400 tons per year. Fuel, charcoal (cold blast). Ores, local magnetic and hematite, foreign and Lake Superior. Brand, "Wyebrooke." Product, car wheel iron.

For analysis of this iron, see Vol. I, p. 82.

Punxsutawney Iron Company, Punxsutawney, Jefferson County. Punxy Furnace. Stacks, 1. Capacity, 85,000 tons per year. Fuel, coke. Ores, Lake Superior red and brown hematites. Brand, "Punxy." Product, foundry and forge irons.

	No. 1 X.	No. 2 X.	No. 2 Plain.	No. 3.	Grey Forge.	No. 1 Soft.	No. 2 Soft.
Silicon	2.750	2.50	2.250	2.000	1.250 to 1.750	2.75 to 3.00	2.50
Phosphorus	.400 to .500	.40 to .50	.400 to .500	.400 to .500	.400 to .500	.40 to .50	.40 to .50
Sulphur	.012 to .020	.03	.035	.045	.050	.02	.03
Manganese	.600 to .700	.60 to .70	.600 to .700	.600 to .700	.600 to .700	.60 to .70	.60 to .70
Combined Carbon	.120	.18	.300	....	....	.18	.22
Graphitic Carbon	3.550	3.30	3.250	....	....	3.45	3.38

Reading Iron Company, Crumwold Furnace at Emaus, Lehigh County, stacks 1, and Keystone Furnace at Reading, Berks County, stacks, 1. Total capacity, 145,000 tons per year. Fuel, anthracite coal and coke. Ores, Lake Superior, hematite and magnetic. No brand. Product, foundry and mill irons. Foundry iron sold to trade, mill iron used entirely in own consumption.

For analysis of this iron, see Vol. I, p. 82.

Republic Iron and Steel Company, Sharon, Mercer County. Hall Furnace. Stacks, 1. Capacity, 50,000 tons per year. Fuel, coke. Ore, Lake Superior. Brand, "Hall." Product, bessemer, mill and foundry irons.

	No. 1.	No. 2.	No. 3.	Mill.
Silicon	2.750	2.25	1.75	1.250
Phosphorus	.600	....	....	.750
Sulphur	.030	....	....	.035
Manganese	.500	....	....	.600
Combined Carbon	.250	....	....	.500
Graphitic Carbon	3.500	....	....	3.250

Running almost exclusively on mill iron for own use.

PENNSYLVANIA (Continued)

Republic Iron and Steel Company, Newcastle, Lawrence County. Atlantic Furnace. Stacks, 1. Capacity, 90,000 tons per year. Fuel, coke. Ore, Lake Superior. Brand, "Atlantic." (Operated by Atlantic Iron and Steel Co.) Product, bessemer iron.

	Bessemer.
Silicon	1.00 to 2.50
Phosphorus	.10 and under
Sulphur	.05 and under
Manganese	.75 about

Robesonia Iron Company, Limited, Robesonia, Berks County. Robesonia Furnace. Stacks, 1. Capacity, 55,000 tons per year. Fuel, coke. Ore, roasted Cornwall alone. Brand, "Robesonia."

For analysis of this iron, see Vol. I, p. 87.

Rockhill Iron and Coal Company, Huntingdon County. Rockhill Furnaces. Stacks, 2. Total capacity, 28,000 tons per year. Fuel, coke. Ores, local fossil and hematite. Brand, "Rockhill." Product, foundry and grey forge irons.

	No. 1.	No. 2.	No. 3.	No. 4.
Silicon	2.890	2.200	1.740	1.050
Phosphorus	.577	.626	.711	.542
Sulphur	.032	.027	.078	.149
Manganese	.627	.588	.354	....

Saxton Furnace Company, Saxton, Bedford County. Saxton Furnaces. Stacks, 2. Total capacity, 90,000 tons per year. Fuel, coke. Ores, native and Lake Superior. Brand, "Saxton." Product, foundry, forge and basic irons.

Could not obtain analysis of this iron.

Sharon Steel Company, The—Sharon, Mercer County. Stacks, 1. Capacity, 200,000 tons per year. Fuel, coke. Ore, Lake Superior. No brand. Product used in own consumption. Additional stacks are projected.

PENNSYLVANIA (Continued)

Sharpsville Furnace Company, Sharpsville, Mercer County. Sharpsville Furnace. Stacks, 1. Capacity, 70,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brand, "Sharpsville." Product, bessemer, foundry and forge irons.

	Bessemer.
Silicon	1.250 to 2.750
Phosphorus	.080 to .095
Sulphur	.010 to .035
Manganese	.750
Combined Carbon	.250
Graphitic Carbon	3.600

Shenango Furnace Company, Sharpsville, Mercer County. Shenango Furnaces. Stacks, 3. Total capacity, 220,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brands, "Douglas" and "Shenango." Product, bessemer, malleable and basic irons.

	Bessemer and Malleable.
Silicon	1.00 to 3.00 as wished
Phosphorus	.10 or under, occasionally .15 for special purposes
Sulphur	.05 or under
Manganese	.75
Combined Carbon Graphitic Combined	Varies with Silicons

St. Clair Furnace Company, Clairton, Allegheny County. Stacks, 3. Annual capacity, 550,000 tons per year. Fuel, coke. Ore, Lake Superior. Product, bessemer and low phosphorus irons.

Could not obtain analysis, as stacks not yet in operation.

Stewart Iron Company, Limited, Sharon, Mercer County. Stewart Furnace. Stacks, 1. Capacity, 82,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brand, "Stewart." Product, bessemer and low-phosphorus irons.

LOW PHOSPHORUS.

Grade No. 1. Guaranteed, Phosphorus not to exceed .03; Silicon not to exceed 1.00 and Sulphur not over .030.
Grade No. 2. Guaranteed, Phosphorus from .031 to .040; Silicon and Sulphur as above.
Grade No. 3. Guaranteed, Phosphorus from .041 to .050; Silicon and Sulphur as above

REGULAR BESSEMER.

Guaranteed, Phosphorus not to exceed .10; Silicon 1.00 to 1.50 and Sulphur not over .050.

In the above grades the silicon is varied to meet the wants of customer, but in no case is the phosphorus or sulphur to exceed the limit of guarantee, as noted. The following is the analyses of six consecutive castings of each grade:

No. 1			No. 2			No. 3			Regular Bessemer		
Sil.	Phos.	Sul.	Sil.	Phos.	Sul.	Sil.	Phos.	Sul.	Sil.	Phos.	Sul.
0.95	.025	.010	0.95	.034	.008	0.90	.045	.010	1.23	.096	.030
0.87	.027	.008	0.91	.034	.006	1.00	.046	.010	1.39	.096	.025
0.96	.026	.006	1.00	.035	.010	0.95	.044	.009	1.24	.093	.020
0.88	.028	.009	1.03	.033	.007	0.98	.047	.012	1.01	.095	.023
0.90	.027	.008	0.98	.034	.009	1.01	.045	.008	1.04	.097	.028
0.93	.026	.008	0.82	.036	.010	0.98	.046	.007	1.20	.093	.010

The variations in the silicon are made to run from ¾ of one per cent up to 3.00% and conform strictly within the limit of guarantee when same is specified in contract.

PENNSYLVANIA (Continued)

Susquehanna Iron and Steel Company, Columbia. Stacks, 2,—one at Vesta, Lancaster County, and one at Wrightsville, York County. Total capacity, 55,000 tons per year. Fuel, anthracite coal and coke. Ores, native, hematite and magnetite. Brands, "Vesta" and "Aurora." Product, foundry and forge irons.

Could not obtain analysis of this iron.

Swatara Furnace, Union Deposit, Dauphin County. Stacks, 1. Capacity, 9,000 tons per year. Fuel, anthracite coal and coke. Ores, magnetite, brown hematite and fossil.

Could not obtain analysis of this iron, as furnace has been idle for a long time.

Temple Iron Company, Temple, Berks County. Temple Furnace. Stacks, 1. Capacity, 50,000 tons per year. Fuel, anthracite coal and coke. Ores, Lake Superior and local hematite and New Jersey magnetic. Brand, "Temple."

This furnace makes only mill iron—analysis depends upon specifications of order. For general analysis of this iron, see Vol. I, p. 88.

Thomas Iron Company, The—Easton, Northampton County. Stacks, 10,—2 at Hellertown, Northampton County, 5 at Hokendauqua, Lehigh County, 2 at Alburtis, Lehigh County, and 1 at Island Park, Northampton County. Total capacity, 240,000 tons per year. Fuel, anthracite coal and coke. Ores, foreign, Lake Superior, local brown hematite and New Jersey magnetic (do not use cinder or by-products of any kind). Product, foundry, forge, bessemer and basic irons. Brand, "Thomas."

	Special Thomas Scotch.	No. 1 X.	Thomas Scotch.	No. 2 X.	No. 2 Soft.	No. 2 Plain.	No. 3 Foundry.	Grey Forge.	Basic.
Silicon.......	3.50 and over	up to 3.50	3.00 and over	up to 3.00	2.50 and over	up to 2.50	1.75 and over	.75 to 1.50	under 1.00
Phosphorus...	.60 to .90	.60 to .90	.60 to .90	.60 to .90	.60 to .90	.60 to .90	.60 to .90	.60 to .90	.60 to .90
Sulphur......	.01 to .03	.01 to .03	.01 to .03	.02 to .03	.035	.04	.05	.06	.02 to .05
Manganese....	.25 to .50	.25 to .50	.25 to .50	.25 to .50	.25 to .50	.25 to .50	.25 to .50	.25 to .50	.50 to .75
Combined Carbon	.25	.30	.35	.40	.50	.60	.65	.70	.50 to .70
Graphitic Carbon	3.45	3.40	3.35	3.30	3.20	3.10	3.00	2.90	3.20 to 2.90

PENNSYLVANIA (Continued)

THE THOMAS IRON COMPANY

System of Grading Foundry Pig Iron.

Special Thomas Scotch.—Large grained iron, grain running out to edges, practically free from spots, bright in color. Sulphur low; silicon 3.50 per cent and over. This is practically No. 1 X, but by reason of being high in silicon, is lighter and brighter in color than No. 1 X.

No. 1 X.—Large grained, strong iron, grain running out to edges, practically free from spots. Sulphur low; silicon in accordance to specification of customer, but in absence of such specification, we supply such silicon as in our judgment the character of work requires.

Thomas Scotch.—Large grained iron, with No. 2 X fracture, but being higher in silicon, is likely to be a little closer in grain, and lighter in color. Sulphur low; silicon 3.00 per cent and over.

No. 2 X.—Large grained, strong iron, grain running well out to edge. Sulphur low, but a little higher than No. 1 X; silicon in accordance with specification of customer, but in absence of such specification, we supply such silicon as in our judgment the character of work requires.

No. 2 Soft.—Foundry fracture, but crystals are smaller than No. 2 X. This is practically high silicon No. 2 plain, but is brighter in color, and being a hotter iron, is usually lower in sulphur than No. 2 plain. Silicon 2.50 per cent and over.

No. 2 Plain.—Foundry fracture, a little close grained at edges. Sulphur higher than No. 2 X. Has greater strength than No. 2 Soft. Silicon supplied as agreed upon, up to 2.50 per cent.

No. 3 Foundry.—This is high silicon iron, with a grey forge fracture, usually a little lower in sulphur than standard grey forge. Silicon 1.75 per cent and over. Shipped to foundries.

Grey Forge.—Close grained iron; used mostly for puddling. No. 3 Foundry and Grey Forge are two grades of grey forge; that high in silicon is shipped to pipe works and other foundries, and that low in silicon, to rolling mills.

Grey Mottled.—Shows some grain, but mostly mottled specks; edges may show some chill. Silicon usually low.

White.—Chilled iron. Some showing face of pig a solid chill, but often showing mottled at center or on bottom of pig. Silicon low.

PENNSYLVANIA (Continued)

THE THOMAS IRON COMPANY.

HOKENDAUQUA WORKS, HOKENDAUQUA, PA.

PENNSYLVANIA (Continued)

THE THOMAS IRON COMPANY.

SAUCON WORKS, HELLERTOWN, PA.

PENNSYLVANIA (Continued)

THE THOMAS IRON COMPANY.

CASTING MACHINE IN OPERATION, SAUCON WORKS.

The iron is run directly from the furnaces into ten-ton ladles and conveyed to casting machine. There it is poured into a series of iron moulds whose hot contents are gradually cooled and automatically loaded into cars. Iron cast by this process is thus rendered free from sand and other external matter.

PENNSYLVANIA (Continued)

THE THOMAS IRON COMPANY.

LOCK RIDGE WORKS, ALBURTIS, PA.

PENNSYLVANIA (Continued)

THE THOMAS IRON COMPANY.

ISLAND PARK WORKS, ISLAND PARK, NEAR EASTON, PA.

PENNSYLVANIA (Continued)

Tidewater Steel Company, The—Chester, Delaware County. Tidewater Furnace. Stacks, 1. Capacity, 60,000 to 70,000 tons per year. Fuel, Connellsville coke. Ores, domestic and foreign. Brand, "Tidewater." Product, bessemer, foundry and basic irons.

	Grey Forge.	Strong Foundry.	Soft Foundry.	O. H. Basic.	Ordinary Bessemer.	Low Phos. Bessemer.
Silicon.........	.900	1.000	2.000	.600	1.500	....
Phosphorus	.500	.200	.500	.500	.095	.075
Sulphur........	.060	.030	.025	.040	.035	....
Manganese	1.000	1.000	.350	.750	.500	....

Valentine Iron Company, Bellefonte, Centre County. Valentine Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, Connellsville coke. Ores, Lake Superior and native hematite. Brand, "Nittany." Product, foundry and forge irons.

For analysis of this iron, see Vol. I, p. 73.

Warwick Iron and Steel Company, Pottstown, Montgomery County. Warwick Furnaces. Stacks, 2. Total capacity, 200,000 tons per year. Fuel, one-fourth anthracite coal and three-fourths coke. Ores, Lake Superior, foreign and local. Brand, "Warwick." Product, Lake Ore foundry, foundry sandless, sandless neutral mill and basic irons.

	No. 1.	No. 2.	No. 3.	No. 4.
Silicon.........	2.500 to 3.000	2.000 to 3.000	.750 to 1.250	.500 to 1.000
Phosphorus.....	.450 to .550	.450 to .550	.450 to .550	.450 to .550
Sulphur.... ...	.001 to .020	.020 to .040	.040 to .080	.080 to .150
Manganese	.400 to .600	.400 to .600	.400 to .600	.400 to .600
Combined Carbon	.200 to .300	.300 to .500	....	....
Graphitic Carbon.	3.750 to 3.950	3.650 to 3.850	....	....
Total Carbon....			3.75 to 4.10	

NOTE.—Aim to grade "sandless" pig by analysis only, as follows:

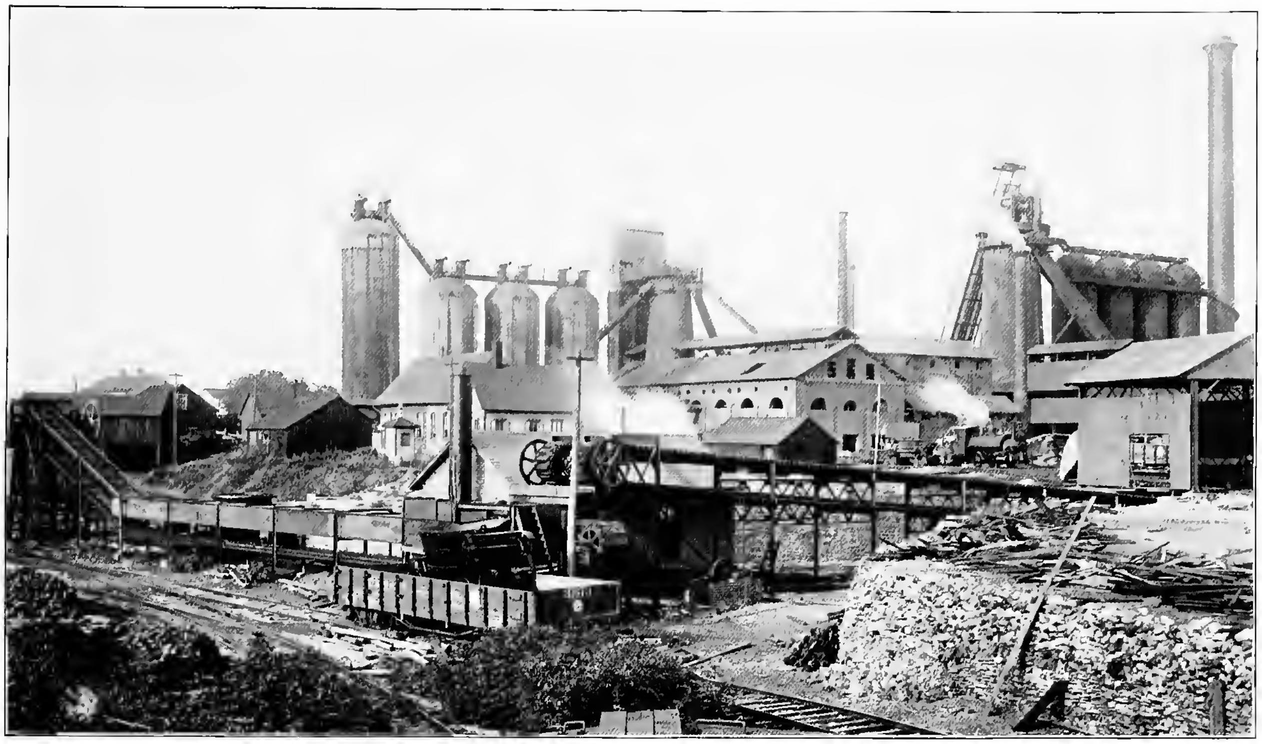
"Scotch"	Silicon over 3.00	Sulphur .03 or less
No. 1 X	Silicon 2.50 to 3.00	Sulphur .03 maximum
No. 2 Soft	Silicon 2.50 to 3.50	Sulphur .05 maximum
No. 2 X	Silicon 2.00 to 2.50	Sulphur .04 maximum
No. 2 Plain	Silicon 1.75 to 2.50	Sulphur .05 maximum
No. 2 Strong	Silicon 1.50 to 2.00	Sulphur .05
No. 3 Foundry	Silicon 1.50 to 2.50	Sulphur .05 to .10

Basic Iron.

Silicon	1.00 and under
Phosphorus	.50
Sulphur	.05 and under

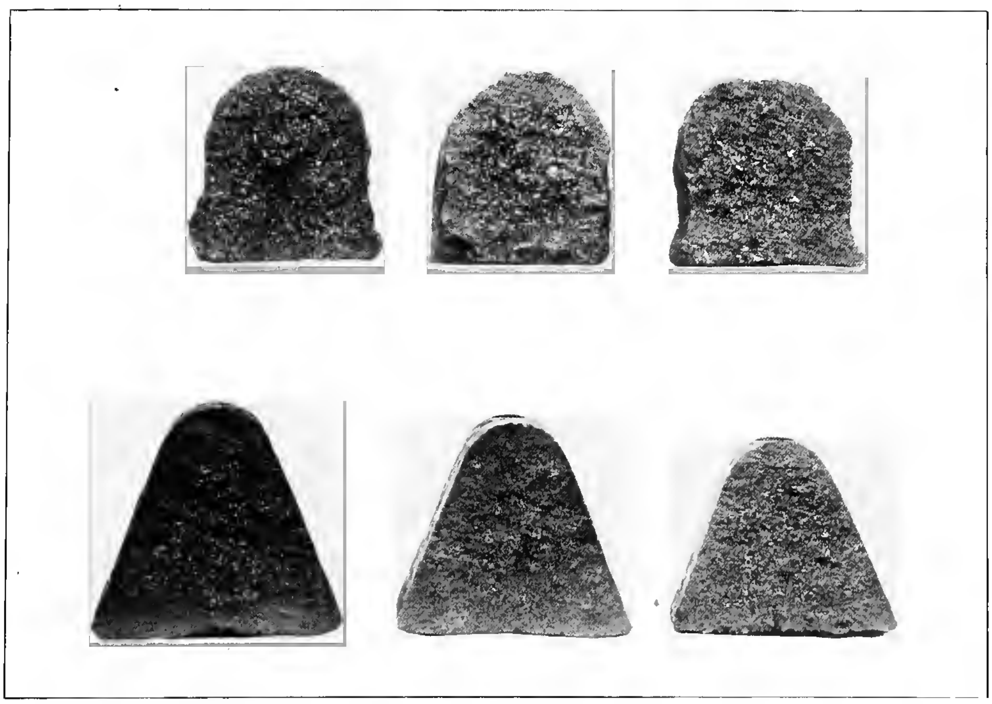
PENNSYLVANIA (Continued)

WARWICK IRON AND STEEL COMPANY.



VIEW OF WARWICK IRON AND STEEL CO.'S BLAST FURNACES.

Machine for casting "Sandless Pig Iron" is shown in the foreground. On the extreme right, the corrugated iron shed is termed "Pouring House." The molten metal is poured from ladle cars into moving molds at this point. A ladle in position for pouring is shown at corner of pouring house. The molten metal after being cast in metal molds, is delivered to conveyer running at right angles, and elevated for direct loading into railroad cars at the extreme left of photograph. The railroad car directly in front contains new ladle just arrived from maker and awaiting to be unloaded. The blast furnaces are shown in the background, No. 1 being on the left and the large, new furnace, designated No. 2, on the extreme right.



(UPPER LINE) (LOWER LINE)
SAND CAST AND SANDLESS PIG IRONS.

As made in casting machine of Warwick Iron and Steel Co.

W. L. SIMS,

President and Treasurer Anniston Rolling Mill Co., Birmingham, Ala., formerly General Manager Empire Steel and Iron Company; one of the foremost authorities on pig iron production in the United States.

TENNESSEE.

Bon Air Coal and Iron Company, Mannie, Wayne County. Stacks, 2. Total capacity, 60,000 tons per year. Fuel, coke. Ore, local brown hematite. Brands, "Mannie" (extra fluid softener, silicon as desired), and "Wayne" (foundry iron).

For analysis of this iron, see Vol. I, p. 90.

Chattanooga Furnace Company, Chattanooga, Hamilton County. Chattanooga Furnace. Stacks, 1. Capacity, 24,000 tons per year. Fuel, coke (low temperature blast). Ores, hard and soft red hematite. Brand, "Chattanooga." Product, foundry iron.

For analysis of this iron, see Vol. I, p. 91.

Citico Furnace Company, Chattanooga, Hamilton County. Citico Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, coke. Ores, red and brown hematite. Brand, "Citico." Product, foundry and forge irons.

	No. 1.	No. .2	No. 3.	No. 4.	Grey Forge.
Silicon	3.00	2.50	2.00	1.75	1.50
Phosphorus	1.45	1.45	1.45	1.45	1.45
Sulphur	.03	.03	.04	.05	.08
Manganese	.80	.80	.75	.70	.65
Combined Carbon	.25	.30	.35	.50	.95
Graphitic Carbon	3.10	3.00	2.95	2.75	2.10

Cranberry Furnace Company, The (Lessee)—Johnson City, Washington County. Johnson City Furnace. Stacks, 1. Capacity, 30,000 tons per year. Fuel, coke. Ore, Cranberry. Brand, "Cranberry." Product, low phosphorus iron.

For analysis of this iron, see Vol. I, p. 92.

Dayton Coal and Iron Company, Ltd., The—Dayton, Rhea County. Stacks, 2. Total capacity, 72,000 tons per year. Fuel, coke. Ores, Tennessee fossil and Georgia hematite. Brand, "Dayton." Product, foundry iron.

Could not obtain analysis of this iron.

TENNESSEE (Continued)

Dover Iron Company (Lessee), Bear Spring, Stewart County. Bear Spring and Dover Furnaces. Stacks, 2. Total capacity, 10,000 tons per year. Fuel, charcoal (cold blast). Ore, brown hematite. Brand, "Dover." Product, iron for chilled rolls.

For analysis of this iron, see Vol. I, p. 93.

La Follette Coal, Iron and Railway Company, La Follette, Campbell County. Searles Furnace. Stacks, 1. Capacity, 125,000 tons per year. Fuel, coke. Ores, red fossiliferous and brown hematite. Product, foundry iron.

Could not obtain analysis of this iron.

Red River Iron Company, Clarksville, Montgomery County. Stacks, 1. Capacity, 45,000 tons per year. Fuel, coke. Ore, brown hematite. Brand, "Red River." Product, foundry, high silicon and Tennessee Scotch irons.

	No. 1.	No. 2.	No. 3.	No. 4.	High Silicon.	No. 1 Scotch.
Silicon	2.500–3.250	2.00–2.50	1.75–2.00	1.25–1.75	5.000–7.000	3.25–4.00
Phosphorus	.60	.60	.60	.60	.60	.60
Sulphur	.005– .030	.01– .04	.02– .05	.03– .06	.005– .030	.02
Manganese	.60	.60	.60	.60	.60	.60
Combined Carbon.	.10	.20	.40	.60	.10	.10
Graphitic Carbon.	3.75	3.65	3.25	3.10	3.25	3.40

Napier Iron Works, Napier, Lewis County. Stacks, 1. Capacity, 22,000 tons per year. Fuel, coke. Ore, brown hematite. Brand, "Napier." Product, foundry iron.

	No. 1.	No. 2.	No. 5.
Silicon	2.740	2.380	1.720
Phosphorus	1.040	1.020	.970
Sulphur	.018	.023	.046
Manganese	.640	.630	.620
Combined Carbon	.520	.470	.380
Graphitic Carbon	3.410	3.120	2.660

Roane Iron Company, Rockwood, Roane County. Rockwood Furnace. Stacks, 2. Total capacity, 116,000 tons per year. Fuel, coke. Ores, soft and hard red hematite. Brand, "Rockwood." Product, foundry iron.

	No. 1.	No. 2.	No. 3.	No. 4.	G. F.	No. 1 Soft.	No. 2 Soft.	No. 1 Silvery.	No. 2 Silvery.
Silicon	2.75	2.25	2.00	1.75	1.50	3.00	3.50	5.00	5.50
Phosphorus	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Sulphur	.02	.02	.03	.04	.07	.02	.03	.04	.04
Manganese	.30	.30	.30	.29	.29	.31	.32	.30	.30
Combined Carbon..	.30	.30	.50	.60	1.00	.30	.20	....	....
Graphitic Carbon..	3.00	3.00	2.80	2.75	2.25	2.90	2.90	2.90	2.60

TENNESSEE (Continued)

Tennessee Coal, Iron and Railroad Company, South Pittsburg, Marion County. South Pittsburg Furnaces. Stacks, 3. Total capacity, 210,000 tons per year. Fuel, coke. Ores, brown and red. Brand, "South Pittsburg." Product, foundry and forge irons.

	No. 1 Foundry.	No. 2 Foundry.	No. 3 Foundry.	No. 2 Soft.	No. 4 Foundry.
Silicon	2.650	2.250	2.140	3.140	2.000
Phosphorus	1.560	1.560	1.570	1.600	1.600
Sulphur	.012	.012	.023	.006	.054
Manganese	.870	.860	1.060	.880	.980

Standard Iron Company, Goodrich, Hickman County. Stacks, 1. Capacity, 25,000 tons per year. Fuel, one-fourth charcoal and three-fourths coke. Ore, brown hematite. Brand, "Standard." Product, foundry iron.

	No. 1 Foundry.	No. 2 Foundry.	No. 3 Foundry.	No. 4 Foundry.	Grey Forge.	No. 2 Soft.	Silver Grey.
Silicon	2.490	2.380	2.070	1.290	1.050	3.300	5.000 to 8.000
Phosphorus	.800	.980	.950	.990	1.120	.920	.910
Sulphur	.030	.033	.030	.034	.042	.023	.014
Manganese	.520	.370	....	....	....	.360	....
Combined Carbon....	.310	.580	....	....	....	.150	....
Graphitic Carbon....	3.090	3.310	....	....	....	2.600	....

Virginia Iron, Coal and Coke Company, Embreville, Washington County. Embreville Furnace. Stacks, 1. Capacity, 45,000 tons per year. Fuel, coke. Ore, local brown hematite. Brand, "Embreville." Product, foundry and malleable pig irons.

For analysis of this iron, see Vol. I, p. 92.

Warner Iron Company, Cumberland Furnace P. O., Dickson County. Stacks, 1. Capacity, 50,000 tons per year. Fuel, coke. Ore, brown. Brand, "Warner." Product, foundry iron.

	No. 1 Soft.	No. 2 Soft.	No. 3 Foundry.	No. 4 Foundry.	Grey Forge.
Silicon ....About	3.00 to 4.00	2.50 to 3.00	2.00 to 3.00	1.50 to 3.00	1.00 to 1.50
Phosphorus .....About	1.50	1.50	1.50	1.50	1.50
Sulphur ....About	.02	.03	.04	.06	.09
Manganese ......About	.40	.40	.40	.40	.40
Combined Carbon.About	.27	.27	.27	.27	.27
Graphitic Carbon.About	3.17	3.17	3.17	3.17	3.17

TEXAS.

Cherokee Iron Company, Rusk, Cherokee County. Star and Crescent Furnace. Stacks, 1. Capacity, 18,000 to 25,000 tons per year. Fuel, charcoal. Ore, brown hematite. Brand, "Star and Crescent." Product, car wheel and foundry irons.

For analysis of this iron, see Vol. 1, p. 94.

Jefferson Iron Company, Jefferson, Marion County. Jefferson Furnace. Stacks, 1. Capacity, 25,000 tons per year. Fuel, charcoal. Ores, local brown, fossiliferous and carbonate. Brand, "Jefferson." Product, malleable, car wheel and foundry irons.

For grading card of this iron, see Vol. I, p. 93.

State of Texas, Rusk, Cherokee County. Old Alcalde Furnace. Stacks, 1. Capacity, 10,000 tons per year. Fuel, charcoal. Ore, brown hematite. Brand, "Old Alcalde." Product, car wheel, foundry and basic irons.

For analysis of this iron, see Vol I, p. 93.

Tassie Belle Furnace, New Birmingham, Cherokee County. Stacks, 1. Capacity, 13,500 tons per year. Fuel, charcoal. Ore, local brown hematite. Brand, "Tassie Belle." Product, car wheel iron.

Could not obtain analysis of this iron, as furnace has been idle for several years.

VIRGINIA.

THE ALLEGHANY ORE AND IRON COMPANY OF VIRGINIA.

Alleghany Furnace at Iron Gate, Alleghany County. Stacks, 1. Capacity, 35,000 tons per year. Fuel, New River coke. Ore, Oriskany limonite. Brand, "Alleghany." Product, foundry, mill and basic irons.

	No. 1	No. 2	No. 3	Grey Forge
Silicon	3.00	2.50	1.75	1.00
Phosphorus	.35	.35	.35	.35
Sulphur	.02	.04	.06	.07
Manganese	1.25	1.25	1.50	1.50
Combined Carbon	.20	.25	.40	.85
Graphitic Carbon	3.80	3.60	3.35	2.75

VIRGINIA (Continued)

THE ALLEGHANY ORE AND IRON COMPANY OF VIRGINIA.

SHENANDOAH FURNACE, SHENANDOAH, VA.
(Controlled by Empire Steel and Iron Co.)

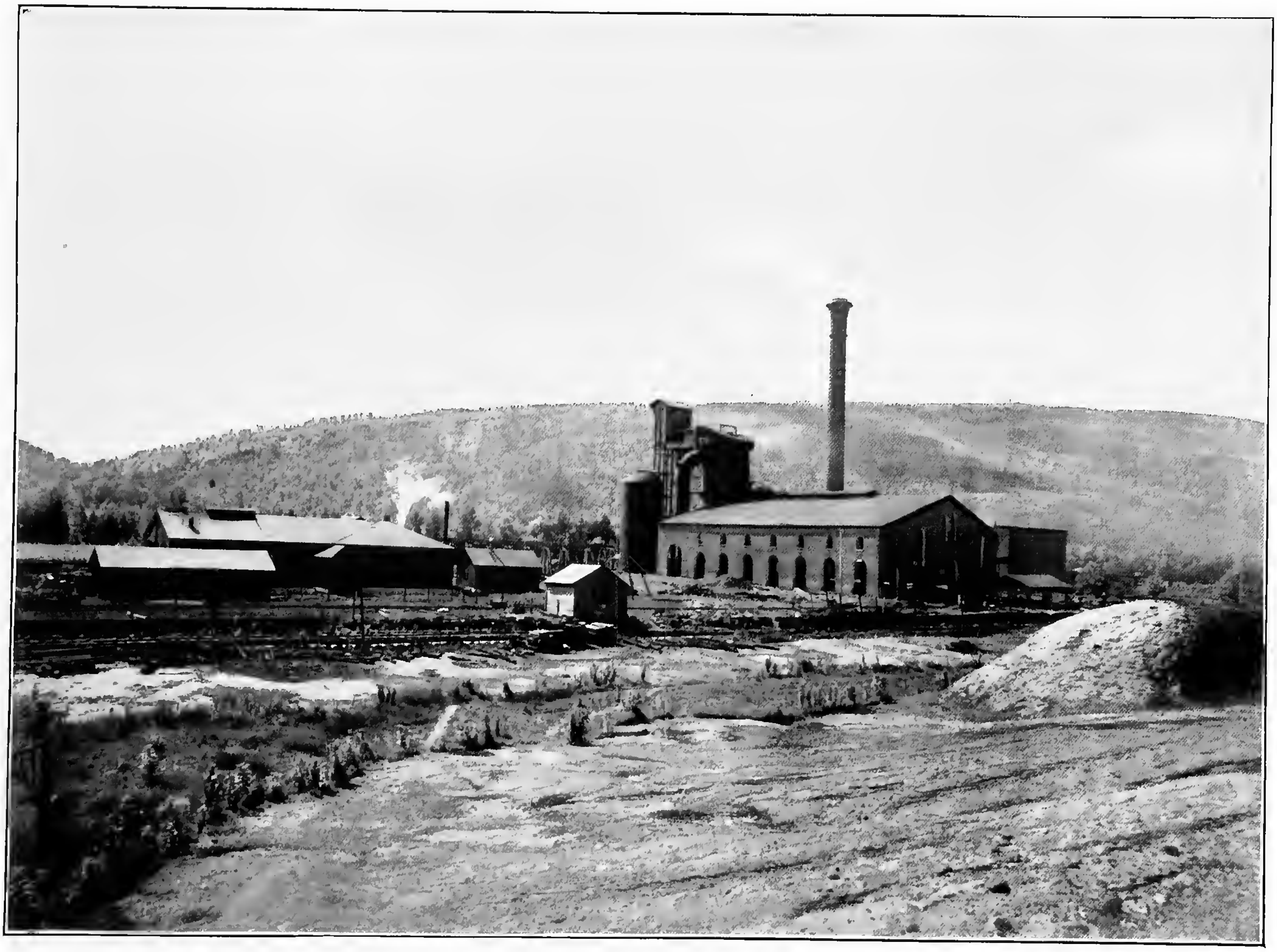
VIRGINIA (Continued)

THE ALLEGHANY ORE AND IRON COMPANY OF VIRGINIA.

VICTORIA FURNACE, GOSHEN, VA.—LOOKING EAST.
(Controlled by Empire Steel and Iron Co.)

VIRGINIA (Continued)

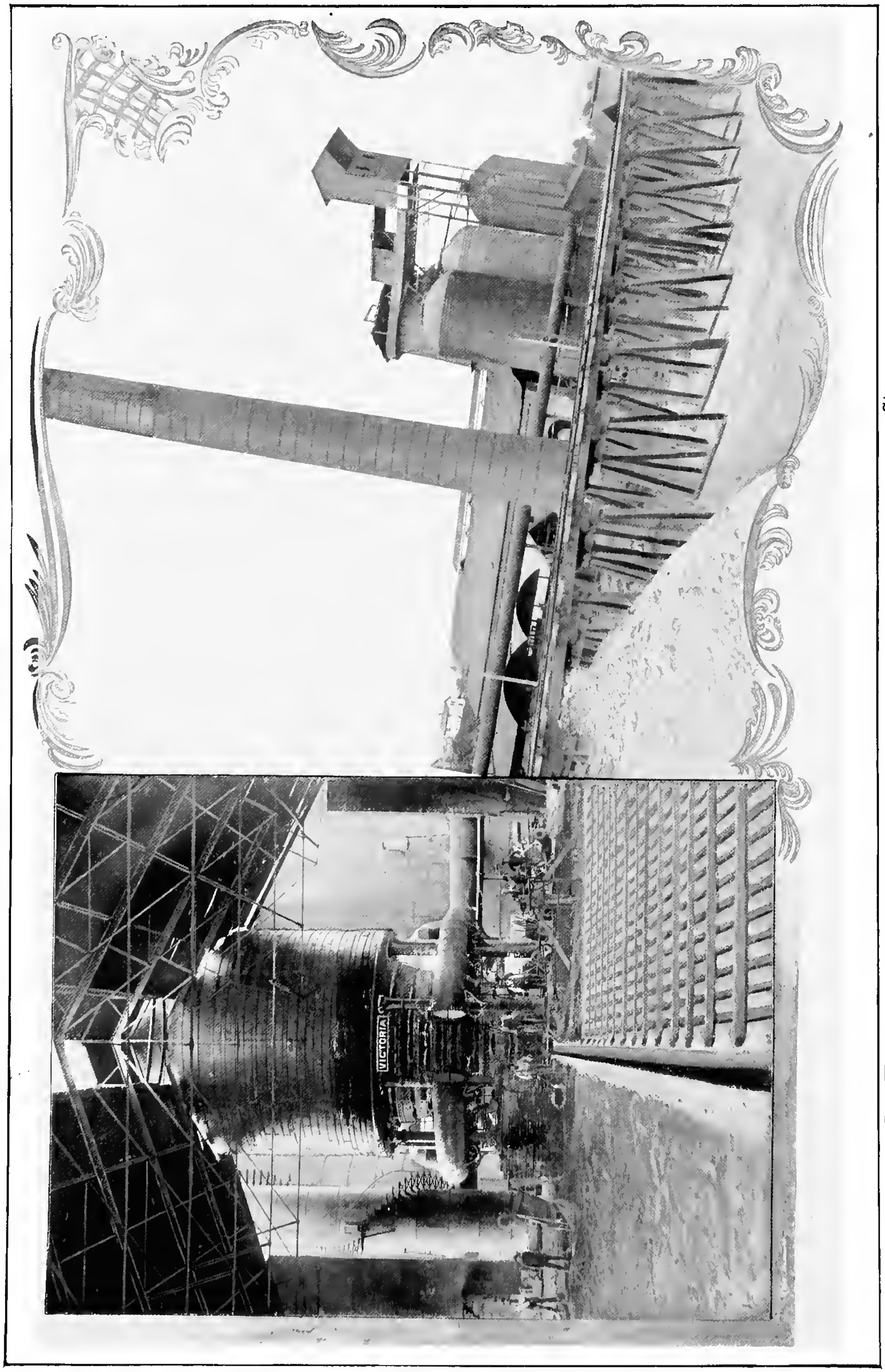
THE ALLEGHANY ORE AND IRON COMPANY OF VIRGINIA.



VICTORIA FURNACE, GOSHEN, VA.—LOOKING SOUTH.
(Controlled by Empire Steel and Iron Co.)

VIRGINIA (Continued)

THE ALLEGHANY ORE AND IRON COMPANY OF VIRGINIA.



Cast House. Stoves.

VICTORIA FURNACE, GOSHEN, VA.
(Controlled by Empire Steel and Iron Co.)

VIRGINIA (Continued)

THE ALLEGHANY ORE AND IRON COMPANY OF VIRGINIA.

Gem Furnace at Shenandoah, Page County. Stacks, 1. Capacity, 55,000 tons per year. Fuel, Pocahontas coke. Ores, native brown hematites and Oriskany limonite. Brand, "Shenandoah." Product, foundry, mill and basic irons.

	No. 1	No. 2	No. 3	Grey Forge	Basic
Silicon	3.000	2.500	2.00	1.00	under 1.00
Phosphorus	.500	.500	.50	.50	.50
Sulphur	.015	.025	.04	.05	under .05
Manganese	1.500	1.500	1.50	1.50	2.00 to 5.00
Combined Carbon	.200	.250	.30	.45	....
Graphitic Carbon	3.750	3.200	2.75	2.50	....

Buena Vista Furnace at Buena Vista, Rockbridge County. Stacks, 1. Capacity, 60,000 tons per year. Fuel, Pocahontas coke. Ore, Oriskany limonite. Brand, "Buena Vista." Product, foundry, mill and basic irons.

	No. 1	No. 2	No. 3	Grey Forge	Basic	Silvery
Silicon	3.00	2.50	2.00	1.00	under 1.00	5.000 to 6.000
Phosphorus	.35	.35	.35	.35	.35	.350
Sulphur	.02	.03	.04	.06	under .05	.015
Manganese	1.00 to 2.00	1.00 to 2.00	1.00 to 2.00	1.00 to 2.00	2.00 to 5.00	1.000
Combined Carbon	.20	.25	.40	.85	.50	.300
Graphitic Carbon	3.75	3.60	3.35	2.75	3.20	3.000

Victoria Furnace at Goshen, Rockbridge County. Stacks, 1. Capacity, 65,000 tons per year. Fuel, New River coke. Ores, Oriskany limonite and native brown hematites. Brand, "Victoria." Product, foundry, mill and basic irons.

	No. 1	No. 2	No. 3	Grey Forge	Basic
Silicon	3.000	2.50	2.00	1.00	under 1.00
Phosphorus	.600	.60	.60	.60	.60
Sulphur	.015	.02	.04	.06	under .05
Manganese	1.250	1.25	1.25	1.25	2.50 to 5.00
Combined Carbon	.200	.25	.30	.45	.60
Graphitic Carbon	3.250	3.00	2.75	2.50	3.15

Big Stone Gap Iron Company, The—Big Stone Gap, Wise County. Stacks, 2. Total capacity, 36,500 tons per year. Fuel, coke. Ore, fossil. Brand, "Big Stone Gap." Product, foundry iron.

For analysis of this iron, see Vol. I, p. 94.

Cedar Run Furnace, Graham's Forge, Wythe County. Stacks, 1. Capacity, 2,500 tons per year. Fuel, charcoal (cold blast). Ore, local. Product, car wheel iron.

Could not obtain analysis of this iron, as furnace has been out of blast for several years.

VIRGINIA (Continued)

Graham Iron Company, Graham, Tazewell County. Graham Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, coke. Ores, fossil and hematites. Brand, "Graham." Product, foundry and basic irons.

For analysis of this foundry iron, see Vol. I, p. 103.

Liberty Furnace, Liberty Furnace P. O., Shenandoah County. Stacks, 1. Capacity, 15,000 tons per year. Fuel, charcoal. Ore, local limonite. Brand, "Liberty."

Not in operation since 1892.

Lobdell Car Wheel Company, of Wilmington, Delaware. White Rock Furnace in Smythe County, Virginia. Stacks, 1. Capacity, 3,600 tons per year. Fuel, charcoal (warm and cold blast). Ore, limonite. Brand, "White Rock."

	No. 3
Silicon	1.633
Phosphorus	.231
Sulphur	.036
Manganese	1.206
Combined Carbon	.570
Graphitic Carbon	2.450

Longdale Iron Company, The—Longdale, Alleghany County. Stacks, 2. Total capacity, 40,000 tons per year. Fuel, coke. Ore, brown hematite. Brand, "Longdale." Product, chiefly basic.

For analysis of this iron, see Vol. I, p. 101.

Low Moor Iron Company of Virginia, The—Low Moor, Alleghany County. Stacks, 3. Total capacity, 100,000 tons per year. Fuel, coke. Ore, local. Brands, "Low Moor" and "Covington." Product, foundry iron.

	No. 1	No. 2	No. 3	No. 4
Silicon	2.50 to 3.50	2.50 to 3.50	2.00 to 3.00	2.00 to 4.00
Phosphorus	.75	.75	.75	.75
Sulphur	.02	.03	.04	.06
Manganese	.70	.70	.70	.70
Combined Carbon	.25	.25	....	....
Graphitic Carbon	3.50	3.25	....	....

New River Mineral Company, Ivanhoe Furnace P. O., Wythe County. Ivanhoe Furnace. Stacks, 1. Capacity, 25,000 tons per year. Fuel, Pocahontas coke. Ores, local brown hematite and limonite. Brand, "Ivanhoe." Product, foundry and forge irons.

Could not obtain analysis of this iron.

VIRGINIA (Continued)

Princess Iron Company, Glen Wilton, Botetourt County. Princess Furnace. Stacks, 1. Capacity, 15,000 tons per year. Fuel, coke. Ore, hematite. Brand, "Princess." Product, foundry iron.

For analysis of this iron, see Vol. I, p. 101.

Pulaski Iron Company, Pulaski City, Pulaski County. Stacks, 1. Capacity, 50,000 tons per year. Fuel, Pocahontas coke. Ores, brown hematite, limonite and Gossan. Product, foundry iron.

For analysis of this iron, see Vol. I, p. 102.

Radford Furnace, Radford Furnace P. O., Pulaski County. Stacks, 1. Capacity, 4,000 tons per year. Fuel, coke. Ore, Max Creek. Product, mill and foundry irons.

Could not obtain analysis of this iron.

Roanoke Furnace Company, Roanoke, Roanoke County. Roanoke Furnace. Stacks, 1. Capacity, 55,000 tons per year. Fuel, coke. Ore, brown hematite. Brand, "Roanoke." Product, foundry, forge and basic open hearth.

For analysis of this iron, see Vol. I, p. 102.

Virginia Iron, Coal and Coke Company, Radford, Montgomery County. Radford-Crane Furnace. Stacks, 1. Capacity, 40,000 tons per year. Fuel, coke. Ores, limonite and mountain. Brand, "Radford." Product, foundry and forge irons.

For analysis of this iron, see Vol. I, p. 103.

Virginia Iron, Coal and Coke Company, Reed Island, Pulaski County. Reed Island Furnace. Stacks, 1. Capacity, 2,500 tons per year. Fuel, charcoal (cold blast). Ore, local hematite. Brand, "Reed Island."

For analysis of this iron, see Vol. I, p. 103.

VIRGINIA (Continued)

Virginia Iron, Coal and Coke Company, Bristol, Washington County. Bristol Furnace. Stacks, 1. Capacity, 45,000 tons per year. Fuel, coke. Ores, brown hematite and fossil. Brand, "Bristol." Product, foundry and forge irons.

For analysis of this iron, see Vol. I, p. 103.

Virginia Iron, Coal and Coke Company, Roanoke, Roanoke County. Crozer Furnaces. Stacks, 2. Total capacity, 90,000 tons per year. Fuel, coke. Ores, Oriskany, limonite and mountain. Brand, "Crozer." Product, foundry and forge irons.

For analysis of this iron, see Vol. I, p. 104.

Virginia Iron, Coal and Coke Company, Pulaski, Pulaski County. Dora Furnace. Stacks, 1. Capacity, 45,000 tons per year. Fuel, coke. Ore, limonite. Brand, "Dora." Product, foundry and forge irons.

For analysis of this iron, see Vol. 1, p. 104.

Virginia Iron, Coal and Coke Company, Max Meadows, Wythe County. Max Meadows Furnace. Stacks, 1. Capacity, 50,000 tons per year. Fuel, coke. Ores, Oriskany, limonite and mountain. Brand, "Crozer."

Analysis of this iron same as that made at Crozer Furnaces of same company, see Vol. I, p. 104.

WASHINGTON.

Pacific Steel Company, The—Irondale, Jefferson County via Port Townsend. Irondale Furnace. Stacks, 1. Capacity, 12,000 tons per year. Fuel, charcoal. Ore, magnetite. No brand. Product, foundry iron.

	No. 1	No. 2	No. 3
Silicon	2.300	1.500	.610
Phosphorus	.160	.160	.180
Sulphur	.035	.070	.037
Manganese	1.100	1.000	1.310
Combined Carbon	.....	.....	.580
Graphitic Carbon	.....	.....	4.120

WASHINGTON (Continued)

THE PACIFIC STEEL COMPANY.

IRONDALE FURNACE, IRONDALE, WASH.

WASHINGTON (Continued)

THE PACIFIC STEEL COMPANY.

No. 1.

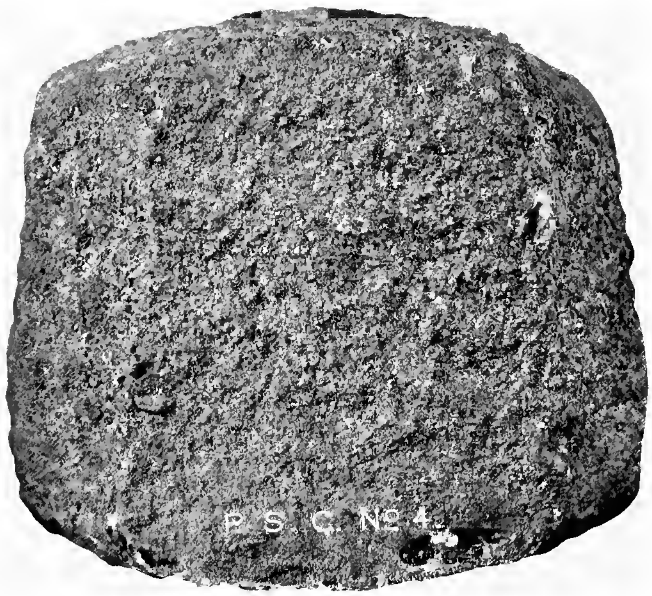
WASHINGTON (Continued)

THE PACIFIC STEEL COMPANY.

No. 3.

WASHINGTON (Continued)

THE PACIFIC STEEL COMPANY.



No. 4.

THE PACIFIC STEEL COMPANY

WASHINGTON MILL COMPANY MILLS, AT HADLOCK, WASHINGTON,

which, in addition to their heavy export and domestic lumber shipments, are supplying The Pacific Steel Company, at Irondale, Washington, with the wood necessary for their charcoal furnaces.

WEST VIRGINIA.

National Tube Company, Benwood, Marshall County. Riverside Furnace. Stacks, 1. Capacity, 90,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. No brand. Product, bessemer iron.

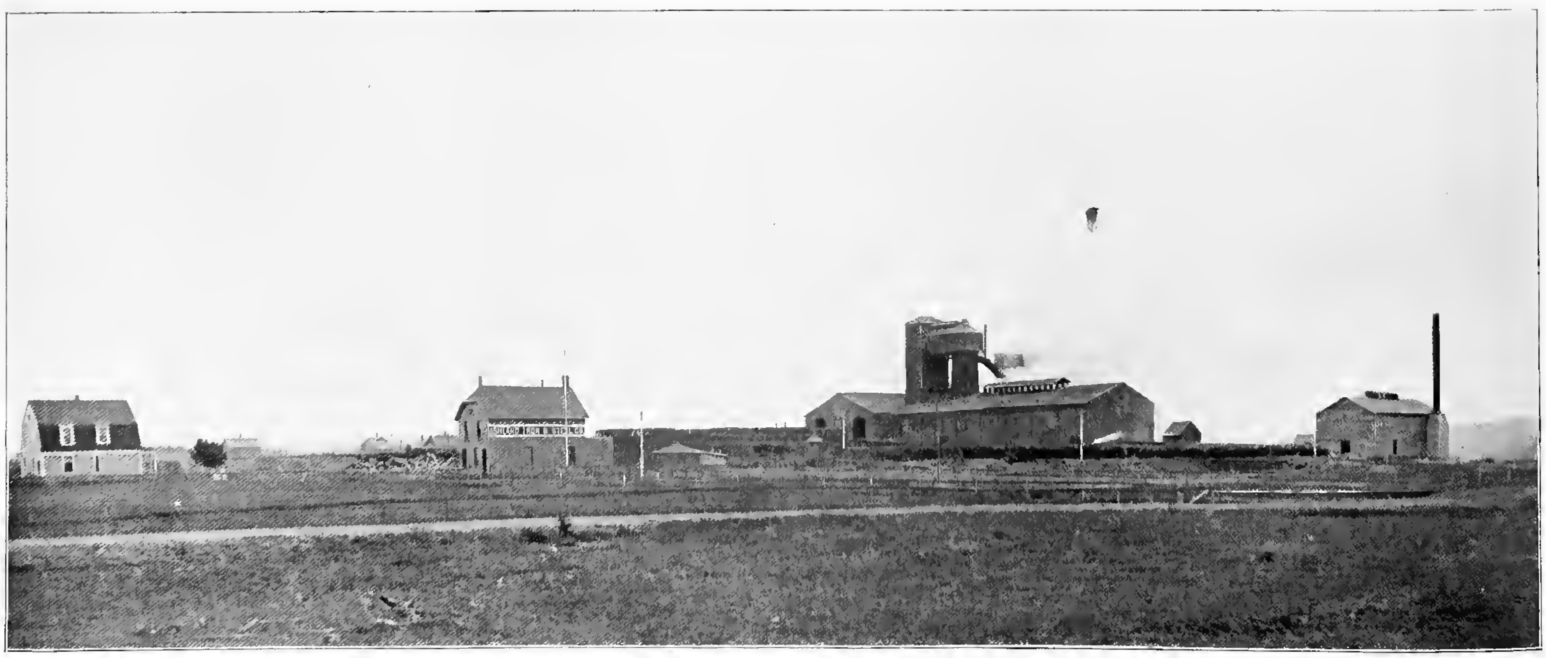
Standard Bessemer	
Silicon	1.500
Phosphorus	.085
Sulphur	.020
Manganese	.850
Combined Carbon / Graphitic Carbon	4.030

Wheeling Steel and Iron Company, Wheeling, Ohio County. Stacks, 2. Total capacity, 150,000 tons per year. Fuel, Connellsville coke. Ore, Lake Superior. Brands, "Belmont" and "Top Mill." Product, bessemer iron.

For analysis of this iron, see Vol. I, p. 105.

WISCONSIN.

Ashland Iron and Steel Company, Ashland, Ashland County. Hinkle Furnace. Stacks, 1. Capacity, 45,000 tons per year. Fuel, charcoal (hot and cold blast). Ore, Gogebic. Brand, "Hinkle." (Hinkle charcoal cold blast furnace, capacity 5,000 tons per year.)



GENERAL VIEW OF THE HINKLE FURNACE.

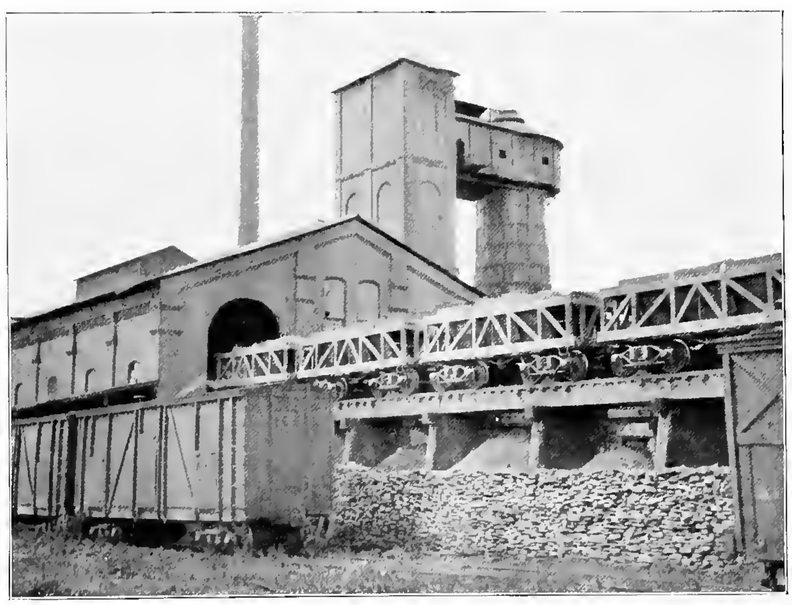
WISCONSIN (Continued)

ASHLAND IRON AND STEEL COMPANY.

LAKE SHIPPING DOCK.

Chequamegon Bay, Lake Superior. View from Casting House.

MAKERS OF "HINKLE" FOUNDRY, MALLEABLE AND CAR WHEEL CHARCOAL IRONS.



HINKLE ORE AND CHARCOAL CARS.

Gogebic Ore.

WISCONSIN (Continued)

ASHLAND IRON AND STEEL COMPANY.

HINKLE GRADING CARD.

Grades	Average Silicon
"A Scotch"	2.75%
"B Scotch"	2.50%
"C Scotch"	2.25%
No. 1 "Soft"	2.00%
No. 1 "Special"	1.75%
No. 1 "Foundry"	1.50%
No. 2 "Low"	1.25%
No. 2 "High"	1.00%
No. 3 "Low"	.80%
No. 3 "Medium"	.65%
No. 3 "High"	.55%
No. 4 "Low"	.45%
No. 4 "High"	.35%
No. 5 "Low"	.30% or less
No. 5 "High"	.20% or less
No. 6 "White"	.10% to trace

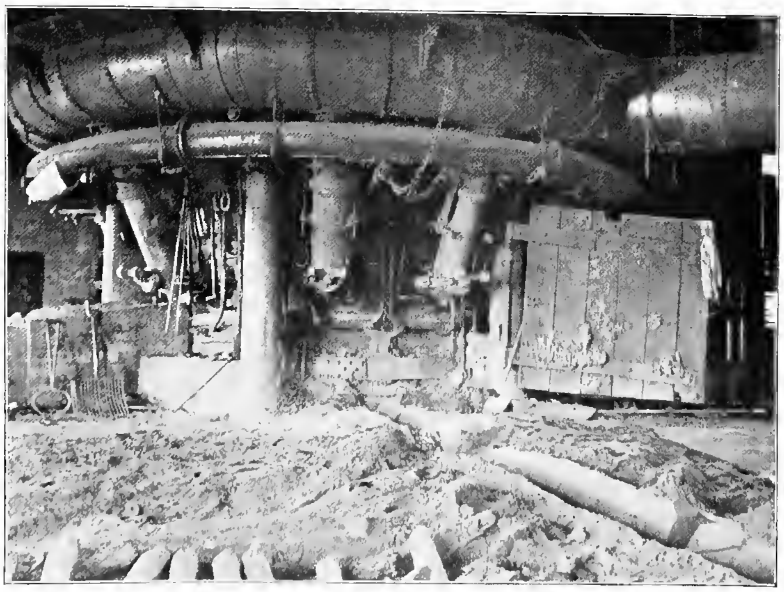
OTHER ELEMENTS.

Manganese	.40 to .60
Phosphorus	.12 to .20
Sulphur	trace to .01
Total Carbon	3.50 to 4.25

The grades from No. 3 "Low" to No. 6, both inclusive, are governed by the grain and chill of the pig in preference to the analysis.

"Special Cylinder," "Special Share," and other extra foundry grades to suit requirements.

"Hinkle Cold Blast." Special product made in small quantities.



HINKLE FURNACE STACK.

WISCONSIN (Continued)

ASHLAND IRON AND STEEL COMPANY.

CHILL CARD OF "HINKLE" PIG IRON WHEN CAST AGAINST THE CHILL-PLATE.

No. 3 "Low"	Feather chill
No. 3 "Medium"	$\frac{1}{8}''$ to $\frac{3}{8}''$
No. 3 "High"	$\frac{3}{8}''$ to $\frac{3}{4}''$
No. 4 "Low"	$\frac{3}{4}''$ to $1\frac{1}{4}''$
No. 4 "High"	$1\frac{1}{4}''$ to $2''$
No. 5 "Low"	Nearly white
No. 5 "High"	All white
No. 6	White iron

CORNER OF CAST AND STOVE HOUSES.

WISCONSIN (Continued)

ASHLAND IRON AND STEEL COMPANY.

HINKLE FURNACE--EARLY MORNING.

HINKLE FURNACE.
Another view of stack and inside of casting-house.

WISCONSIN (Continued)

Northwestern Iron Company, The—Mayville, Dodge County. Mayville Furnace. Stacks, 1. Capacity, 60,000 tons per year. Fuel, coke. Ores, Menominee, Gogebic and local. Brands, "Sidney" and "Gertrude." Product, bessemer and foundry irons.

For analysis of this iron, see Vol. I, p. 107.

Spring Valley Iron Company, Spring Valley, Pierce County. Stacks, 1. Capacity, 28,000 tons per year. Fuel, coke. Ore, brown hematite. Brand, "Spring Valley." Product, malleable, foundry and forge irons.

For analysis of this iron, see Vol. I, p. 107.

Thomas Furnace Company, The—Milwaukee. Minerva Furnace. Stacks, 1. Capacity, 75,000 tons per year. Fuel, coke. Ore, Lake Superior. Brand, "Minerva." Product, foundry, malleable and bessemer irons.

For analysis of this iron, see Vol. I, p. 107.

Illinois Steel Company, Milwaukee Works, Milwaukee. Stacks, 2. Total capacity, 130,000 tons per year. Fuel, Connellsville coke. Ores, Lake Superior and Gogebic. Brands, "Bay View" and " Bay View Scotch" for foundry iron, divided into two classes, based—

Primarily Phosphorus.........	.40 and under
Second Phosphorus...........	.80 and under

Practically all sold by fracture, grades being 1, 2, 3, 4 and 5.

Nos. 1 and 2. All guaranteed under .05 in sulphur
Nos. 3 and 4. May exceed this amount
No. 1. Silicon ranges from 1.75 to 2.25
No. 2. Silicon ranges from 1.25 to 1.75
No. 3. Silicon practically all under 1.50
Manganese in all of above at about .75.
In a general way Combined and Graphitic Carbon
will run about 4.00 or a trifle under.

MALLEABLE BESSEMER.

Practically all sold on analysis specification.

In a general way

Silicon.........	Will run from about 1.00 to 1.75
Phosphorus.....	.20 or under
Sulphur........	Ordinarily under a guarantee of .05 or under
Manganese	Ranges from .75 to 1.40 (always below Silicon)

Bessemer Iron made is of same grade as that made by this Company, see page 50 of this volume.

ENGLAND

CUMBERLAND.

Bain, Jas. and Company, Harrington. Stacks, 4. Ore, hematite. Brand, "Harrington."

	Nos. 1, 2 and 3.
Silicon	2.50 to 3.00
Phosphorus	.04
Sulphur	trace to .03
Manganese	.40
Graphitic Carbon	3.80

Cammel, Chas. and Company, Ltd., Maryport and Workington. Brands, "Solway" and "Derwent."

Could not obtain analysis of this iron.

Distington Hematite Iron Company, Ltd., Distington, Workington. Capacity, 70,000 tons per year. Fuel, best Durham and Newcastle coke. Ore, native Cumberland hematite. Brand, "Distington" (hematite).

For analysis of this iron, see Vol. I, p. 111.

Kirk Brothers and Company, Ltd., Workington. Brands, "Reedlands," "Marron" and "Westfield."

This company's output is all used by themselves for the manufacture of bar iron and castings.

Lonsdale Hematite Smelting Company, Ltd., Whitehaven. Brand, "Lonsdale."

Could not obtain analysis of this iron.

Lowther Hematite Iron and Steel Company, Ltd., Workington. Brand, "Lowther."

Could not obtain analysis of this iron, as works are not now in operation.

Millom and Askam Hematite Iron Company, Ltd., The—Millom. Stacks, 6. Total capacity, 175,000 tons per year. Fuel, best Durham coke. Ores, Hodbarrow and other Cumberland and Furness native hematites. Brands, "Millom Hematite" and "M. H. M." (refined).

MILLOM.

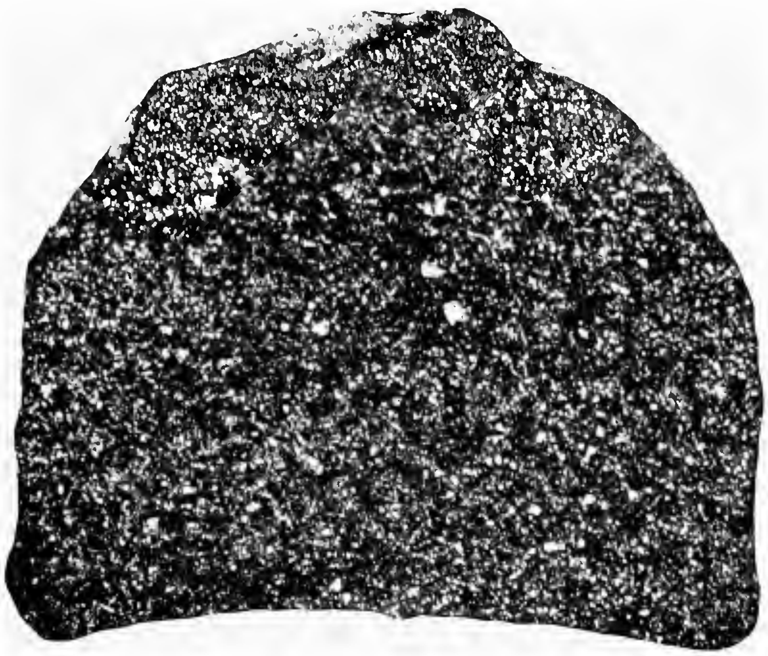
	Special.	No. 1.	No. 2.	No. 3.	No. 4.	No, 5.	Mottled.	White.
Silicon	1.000 to 3.000	1.000 to 3.000	1.000 to 3.000	1.000 to 3.000	1.200	.900	.550	.560
Phosphorus	max. .025	.030	.031	.031	.034	.034	.036	.038
Sulphur	max. .025	trace to .030	trace to .030	trace to .030	.100	.130	.130	.150
Manganese	.500	.500 to .800	.500 to .800	.500 to .800	.600	.400	.250	.200
Combined Carbon	.180	.180	.190	.250	.590	1.330	1.700	3.000
Graphitic Carbon	3.750	3.750	3.480	3.220	2.720	2.600	1.500	.100

CUMBERLAND (Continued)

THE MILLOM AND ASKAM HEMATITE IRON COMPANY, LTD.

	M. H. M.				
	White.	Spotted White.	Hard Mottled.	Soft Mottled.	Grey.
Silicon	.500	.600	.940	.740	1.200
Phosphorus	.037	.037	.036	.036	.036
Sulphur	.150	.160	.200	.160	.130
Manganese	.200	.200	.200	.200	.200
Combined Carbon..	3.000	3.100	.770	.740	1.000
Graphitic Carbon..	.110	.100	2.600	2.100	2.400

NOTE.—Free from Copper throughout, and, if required, east in moulds free from sand.



FRACTURE OF No. 1 MILLOM HEMATITE MADE AT MILLOM IRONWORKS, MILLOM, CUMBERLAND.

CUMBERLAND (Continued)

THE MILLOM AND ASKAM HEMATITE IRON COMPANY, LTD.

MILLOM IRONWORKS, MILLOM, CUMBERLAND.

CUMBERLAND (Continued)

Moss Bay Hematite Iron and Steel Company, Ltd., Workington. Brand, "Mosbay."

Could not obtain analysis of this iron.

North Western Iron and Steel Company, Ltd., The—Workington. Average output, 78,000 tons per year. Fuel, hard coke and Splint coal. Ores, local Cumberland hematite and best Spanish. Brand, "N. W. Co."

For analysis of this iron, see Vol. I, p. 112.

Whitehaven Hematite Iron and Steel Company, Ltd., Cleator Moor. Brands, "Cleator" and "H. C. M." (hematites).

CLEATOR.

	Average Analysis.
Silicon	1.931
Phosphorus	.041
Sulphur	trace
Manganese	trace
Combined Carbon	.320
Graphitic Carbon	2.993

Workington Iron Company, Ltd., The—Workington. Brand, "Workington."

At present manufacturing Spiegeleisen only.

DERBYSHIRE.

Butterley Company, Ltd., Alfreton. Brand, "Butterley."

Could not obtain analysis of this iron.

Clay Cross Company, near Chesterfield. Brands, "C x C" and "Clay Cross."

No. 1 Clay Cross.

Silicon	3.33
Phosphorus	.54
Sulphur	.02
Manganese	.21
Combined Carbon	.64
Graphitic Carbon	2.47

DERBYSHIRE (Continued)

Davis, E. P. Bennerley and Erewash Furnaces. Brand, "Awsworth."

Could not obtain analysis of this iron.

Denby Iron and Coal Company, Ltd., near Derby. Brands, "Denby Iron Co." and "D. D. D."

Could not obtain analysis of this iron.

Oakes, James and Company—Alfreton. Brand, "0 0 0 0."

Could not obtain analysis of this iron.

Renishaw Iron Company, Eckington, Sheffield. Brand, "Renishaw."

Could not obtain analysis of this iron.

Sheepbridge Coal and Iron Company, Ltd., The—Near Chesterfield. Fuel, coal and coke. Ores, Oolitic of Northamptonshire and Lincolnshire. Brand, "Sheepbridge."

For analysis of this iron, see Vol. I, p. 113.

Stanton Ironworks Company, Ltd., Stanton Gate, Nottingham. Brand, "Stanton."

Could not obtain analysis of this iron.

Staveley Coal and Iron Company, Ltd., near Chesterfield. Brand, "Staveley."

BROAD OAKS FURNACES.

Stacks, 3. Fuel, one-third coke, two-thirds hard coal. Ores, Northamptonshire, Leicestershire and Lincolnshire brown hematites. Total capacity, 46,800 tons per year.

	No. 1.	No. 2.	No. 3.	No. 4 Foundry.	No. 4 Grey Forge.	—No. 4 Forge.—	
Silicon	3.27	3.52	3.09	2.68	2.38	3.27	2.01
Phosphorus	1.29	1.24	1.35	1.27	1.40	1.45	1.35
Sulphur	.02	.05	.05	.07	.07	.08	.11
Manganese	.74	1.06	.93	1.73	1.73	.97	.93
Combined Carbon	.22	.27	.31	.29	.25	.33	.37
Graphitic Carbon	3.06	3.16	3.12	3.12	3.16	3.18	.12

DERBYSHIRE (Continued)

STAVELEY COAL AND IRON COMPANY, LTD.

STAVELEY WORKS.

Stacks, 8. Fuel, one-sixth coke, five-sixths hard coal. Ores, Northamptonshire, Leicestershire and Lincolnshire brown hematites. Capacity, 96,000 tons per year.

	No. 1.	No. 2.	No. 3.	No. 4 Foundry.	No. 4 Grey Forge.	No. 4 Forge		No. 5.	Mottled.	White.	Glazed.
Silicon	3.08	2.80	2.50	2.45	2.40	3.38	1.61		.96	.45	4.50
Phosphorus	1.43	1.58	1.49	1.27	1.41	1.40	1.42		1.44	1.36	....
Sulphur	.03	.04	.04	.07	.08	.08	.12	Same as	.19	.15	....
Manganese	1.22	.85	1.12	.97	1.35	.95	.80	No. 4 Forge	1.30	1.33	....
Combined Carbon	.30	.27	.31	.29	....	.32	.58		1.08	3.10	....
Graphitic Carbon	3.30	3.16	3.12	3.12	....	3.40	2.92		2.18	.90	....

DURHAM.

Bell Brothers, Ltd., Clarence Iron Works, Port Clarence, Middlesbrough. Furnaces, built 12, blowing 10. Capacity, 320,000 tons per year. Fuel, coke. Ore, Cleveland ironstone. Brand, "Clarence."

For analysis of this iron, see Vol. I, p. 113.

Carlton Iron Company, Ltd., Ferryhill. Brand, "Carlton."

Could not obtain analysis of this iron.

Consett Iron Company, Ltd., Blackhill, R. S. O., (Co. Durham.) Brand, "Consett."

Could not obtain analysis of this iron.

Palmers Shipbuilding and Iron Company, Ltd., Jarrow-on-Tyne. Stacks, 5. Capacity, 1 Cleveland furnace, 35,000 tons per year, and 4 Hematite, each 52,000 tons per year. Fuel, coke. Ores, Spanish, Algerian and English Cleveland. Brands, "Jarrow" and "Tyneside."

For analysis of this iron, see Vol. I, p. 114.

DURHAM (Continued)

PALMERS SHIPBUILDING AND IRON COMPANY, LTD.

Yours Sincerely
Charles McLaren

CHARLES B. B. McLAREN, ESQ., M. P.
Chairman of the Company.

DURHAM (Continued)

PALMERS SHIPBUILDING AND IRON COMPANY, LTD.

SIR CHARLES MARK PALMER, Bart., M. P.
Founder of the Works.

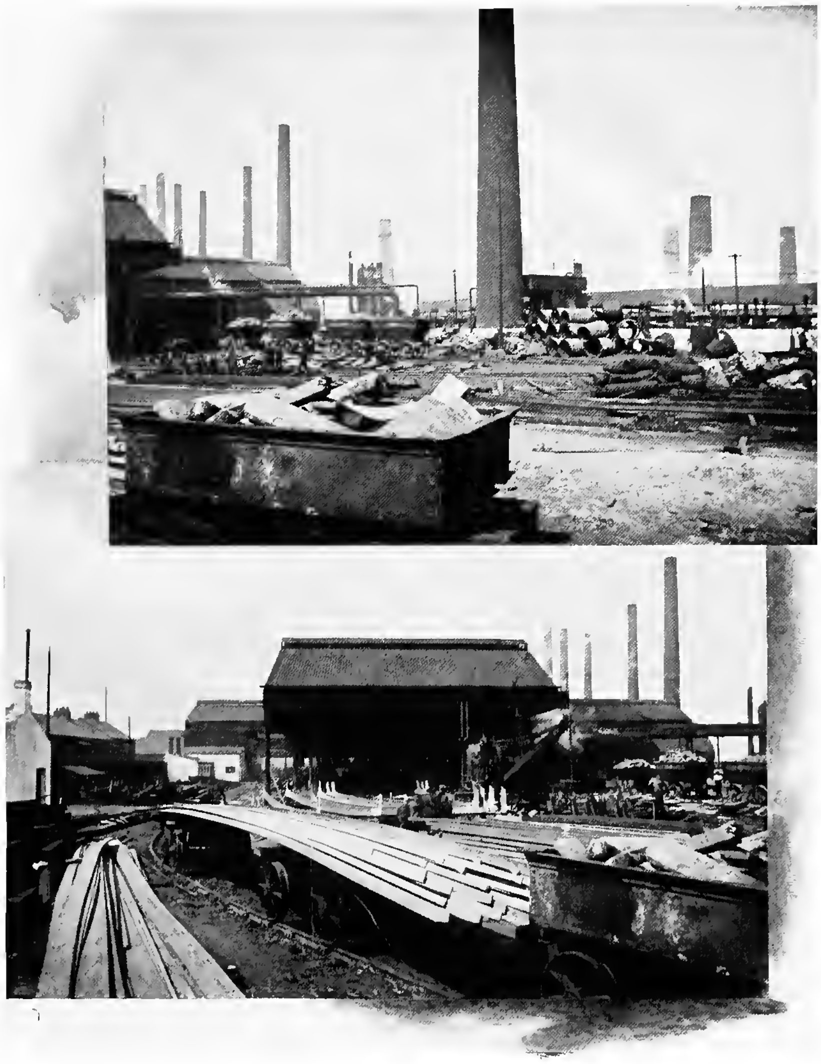
DURHAM (Continued)

PALMERS SHIPBUILDING AND IRON COMPANY, LTD.

BLAST FURNACES.

DURHAM (Continued)

PALMERS SHIPBUILDING AND IRON COMPANY, LTD.



STEEL WORKS.

DURHAM (Continued)

Seaton Carew Iron Company, Ltd., The—West Hartlepool. Capacity, 120,000 tons per year. Fuel, coke. Ores, Spanish and Algerian. Brands. "Seaton Carew" and "Seaton Basic."

	Ordinary.	Special.	Ferro Silicon.
Silicon	2.500	2.00	12.14
Phosphorus	.045	.03	.03
Sulphur	.025	.01	.10
Manganese	1.250	1.35	3.12
Combined Carbon	.450	.35	.25
Graphitic Carbon	3.700	3.85	1.65

Tees-Bridge Iron Company, Ltd., The—Stockton-on-Tees. Stacks, 3. Ores, Cleveland, Yorkshire, England. Fuel, coke. Brand, "Tees-Bridge" (Cleveland quality).

This iron is not sold by analysis.

Weardale Steel, Coal and Coke Company, Ltd., Spennymoor. Brands, "Weardale," "Tudhoe" and "Hematite."

Could not obtain analysis of this iron.

Whitwell, Wm., and Company, Ltd., Thornaby Iron Works, Stockton-on-Tees. Stacks, 3. Total capacity, 125,000 tons per year. Fuel, Durham coke. Ores, Mixture, Spanish from Bilbao as a basis. Brand, "Thornaby Hematite."

	No. 1.	No. 2.	No. 3.	No. 4.
Silicon	2.500	2.350	2.00	1.50
Phosphorus	.040	.040	.04	.04
Sulphur	.025	.035	.05	.10
Manganese	1.100	1.000	.90	.60
Combined Carbon	.100	.200	.30	.50
Graphitic Carbon	4.000	3.800	3.50	2.90

LANCASHIRE.

Barrow Hematite Steel Company, Ltd., Barrow-in-Furness. Brands, "Barrow" and "B. H. S." (Hematites.)

	No. 1.	No. 2.	No. 3.	White.
Silicon	2.942	2.750	2.407	.658
Phosphorus	.050	.054	.060	.062
Sulphur	.048	.055	.065	.348
Manganese	.537	.402	.410	.076
Carbon	3.650	3.480	3.365	3.400

Carnforth Hematite Iron Company, Ltd., Carnforth. Brand, "Carnforth Hematite."

Could not obtain analysis of this iron.

LANCASHIRE (Continued)

Darwen and Mostyn Iron Company, Ltd., Darwen. Brand, "Darwen."

Could not obtain analysis of this iron.

Harrison, Ainslie and Company, Ltd., Backbarrow, near Ulverston. Stacks, 1. Capacity, 1,600 tons per year. Fuel, wood charcoal. Ore, local hematite. Brand, "Lorn" (cold blast). Product, grey, mottled and white, specially made for work of exceptional strength and quality, and is either used by itself or as a mixture with other irons as a refining agent.

Millom and Askam Hematite Iron Company, Ltd., The—Askam. Stacks 3, and 1 building. Fuel, best Durham coke. Ores, Furness hematites and Hodbarrow. Total capacity, 75,000, to be increased to 150,000 tons per year. Brand, "Askam."

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	Mottled.	White.
Silicon	1.000 to 3.000	1.000 to 3.000	1.000 to 3.000	1.300	1.000	.600	.49
Phosphorus	.035	.035	.035	.036	.038	.039	.04
Sulphur	trace to .030	trace to .030	trace to .030	.100	.140	.150	.16
Manganese	.500 to .700	.500 to .700	.500 to .700	.500 to .700	.800	.190	.20
Combined Carbon	.200	.210	.300	.700	1.200	1.600	2.80
Graphitic Carbon	3.500	3.400	3.260	2.560	2.500	1.500	.30

North Lonsdale Iron and Steel Company, Ltd., Ulverston. Brands, "Ulverston," "U. H. M." and "U. V. C."

Could not obtain analysis of this iron.

Wigan Coal and Iron Company, Ltd., Wigan. Stacks, 10. Fuel, coke. Brand, "K. H."

	Ferro Manganese.	Spiegeleisen.	Silico Spiegel.	K. H. Foundry Pig.	K. H. Forge Pig.
Silicon	.50	.60	10.17	2.80	1.80
Phosphorus	.25	.06	.07	.75	.80
Sulphur	nil	trace	trace	.06	.07
Manganese	80.50	20.60	20.00	2.00	1.80
Combined Carbon	7.00	5.17	2.10	.80	1.70
Graphitic Carbon	.....	.....	.....	2.20	1.30

LEICESTERSHIRE.

Holwell Iron Company, Ltd., Ashford by Melton Mowbray. Brand, "Holwell."

Could not obtain analysis of this iron.

LINCOLNSHIRE.

Appleby Iron Company, Ltd., Frodingham via Doncaster. Brand, "Doncaster."

	No. 1.		No. 3.	
Silicon	2.250 to 2.75		2.250 to 2.50	
Phosphorus	1.300 to 1.40		1.300 to 1.40	
Sulphur	.025	....	.030	....
Manganese ....about	1.700	...	about 1.700	....
Combined Carbon....	.185	....	.200	....
Graphitic Carbon....	3.012	....	3.030	....

Frodingham Iron and Steel Company, near Doncaster. Stacks, 1. Capacity, 75,000 tons per year. Fuel, South Yorkshire coke. Ore, Frodingham ironstone. Brand, "Frodingham."

For analysis of this iron, see Vol. I, p. 116.

North Lincolnshire Iron Company, Ltd., The— Frodingham. Capacity, 86,000 tons per year. Fuel, coke. Brand, "N. L. B."

For analysis of this iron, see Vol. I, p. 116.

Redbourn Hill Iron and Coal Company, Ltd., Doncaster. Brand, "Redbourn Allmine."

Could not obtain analysis of this iron.

Shakespeare, Wm., Trent Iron Works, Scunthorpe. Capacity, 36,000 tons per year. Fuel, Yorkshire coke. Brand, "Trent.'

	No. 3 Foundry.	No. 4 Foundry.
Silicon	2.50	1.998
Phosphorus	1.30	1.230
Sulphur	.03	.037
Manganese	1.80	1.729
Combined Carbon	.30	.610
Graphitic Carbon	3.00	2.650

MONMOUTHSHIRE.

Blaenavon Company, Ltd., Blaenavon. Stacks, 2. Fuel, bituminous coal from own collieries. Ore, best Bilbao Rubio. Capacity, 85,000 tons per year. Brand, "Blaenavon."

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	3.00	3.50	3.50	2.50	2.00
Phosphorus	.06	.06	.06	.06	.06
Sulphur	.05	.05	.05	.05	.05
Manganese	.75	.75	.75	.75	.75
Combined Carbon	.50	.50	.75	.80	1.00
Graphitic Carbon	3.00	2.50	2.50	2.00	2.00

MONMOUTHSHIRE (Continued)

Ebbw Vale Steel, Iron and Coal Company, Ltd., The—Ebbw Vale R. S. O. Ore, Bilbao Rubio. Brands, ''Ebbw Vale'' and ''Victoria.''

For analysis of this iron, see Vol. I, p. 117.

Guest, Keen and Company, Ltd., Cwmbran, Newport. Brand, ''P. N. B. Co.''

Could not obtain analysis of this iron.

Pyle and Blaina Works, Ltd., Blaina. Brand, ''Star.''

Could not obtain analysis of this iron.

Rhymney Iron Company, Ltd., Rhymney, via Cardiff.

Could not obtain analysis of this iron, as at present not making any.

Tredegar Iron and Coal Company, Ltd., Tredegar. Brand, ''Tredegar.''

Could not obtain analysis of this iron.

NORTHAMPTONSHIRE.

Butlin, Thos. and Company, Ltd., Irthlingborough Iron Works, Wellingborough. Capacity, 48,000 tons per year. Fuel, coal and coke. Ore, brown hematite (a hydrated sesquioxide). Brand, ''Butlin.''

For analysis of this iron, see Vol. I, p. 118.

Islip Iron Company, Finedon, Wellingborough and Thrapston. Brands, ''Finedon'' and ''Islip.''

Could not obtain analysis of this iron.

Kettering Iron and Coal Company, Ltd., The—Kettering. Stacks, 3. Annual capacity, 65,000 tons. Fuel, Derbyshire hard coal and South Yorkshire coke. Ore, Oolitic. Brand. ''Kettering.''

	No. 1.	No. 2.	No. 3.
Silicon	2.261	2.23	2.159
Phosphorus	1.644	1.62	1.820
Sulphur	.020	.03	.019
Manganese	.472	.32	.275
Combined Carbon..	.248	....	.....
Graphitic Carbon..	3.186	2.68	3.100

New Cransley Iron and Steel Company, Ltd., Kettering. Brand, ''Cransley.''

Could not obtain analysis of this iron.

NORTHAMPTONSHIRE (Continued)

Phipps, P. (Exrs. of) Hunsbury Hill Iron Works, Northampton. Brand. "Northampton."

Could not obtain analysis of this iron.

Wellingborough Iron Company, Ltd., The—Wellingborough. Brand, "Rixons W'boro'."

Could not obtain analysis of this iron.

NORTHUMBERLAND.

Armstrong, Sir W. G., Mitchell and Company, Ltd., Newcastle-on-Tyne. Brand, "Ridsdale Hematite."

For analysis of this iron, see Vol. I, p. 119.

NOTTINGHAMSHIRE.

Bestwood Coal and Iron Company, Ltd., Bestwood, near Nottingham. Capacity, 80,000 tons per year. Fuel, Nottingham coal with a little Derbyshire and Yorks coke. Brand, "Bestwood."

For analysis of this iron, see Vol. I, p. 119.

SHROPSHIRE.

Foster, W. O., Madeley. Brand, "Madeley Court."

Could not obtain analysis of this iron.

Lilleshall Company, Ltd., Shifnal. Capacity, 30,000 tons per year. Fuel, coke. Brands, "Lilleshall Lodge" (C. B.) and "Lilleshall H. B."

For analysis of this iron, see Vol. I, p. 119.

Madeley Wood Company, near Ironbridge. Brand, "Madeley Wood Co." (cold blast).

Could not obtain analysis of this iron.

STAFFORDSHIRE, NORTH.

Butterley Company, Ltd., Stoke-on-Trent. Brand, "W. S. S."

Could not obtain analysis of this iron.

Chatterley-Whitfield Collieries, Ltd., Tunstall. Stacks, 3. Total capacity, 900 tons per week. Fuel, coal— Cockshead and Hardmine. Brand, "Chatterley."

For analysis of this iron, see Vol. I, p. 120.

Goldendale Iron Company, Tunstall and Stoke-on-Trent. Brand, "G. D. C."

Could not obtain analysis of this iron.

Heath, Robert and Sons, Ltd., Tunstall and Stoke-on-Trent. Brands, "Heath and Sons" and "R. H. & S."

Could not obtain analysis of this iron.

Midland Coal, Coke and Iron Company, Ltd., Newcastle.

Could not obtain analysis of this iron.

Shelton Iron, Steel and Coal Company, Ltd., Stoke-on-Trent. Brands, "Granville" and "Shelton."

Could not obtain analysis of this iron.

Stafford Coal and Iron Company, Ltd., Gt. Fenton, Stoke-on-Trent. Stacks, 4. Total capacity, 60,000 tons per year. Fuel, ash. Ore, Blackband. Brand, "Fenton."

	No. 1.	No. 2.	No. 3.	No. 4 Grey.
Silicon	3.037	2.884	2.661	2.271
Phosphorus	1.121	1.030	.997	.989
Sulphur	.020	.025	.032	.047
Manganese	2.089	1.986	1.981	1.992
Combined Carbon.	....	....	.330	.402
Graphitic Carbon.	3.880	3.621	2.640	2.598

STAFFORDSHIRE, SOUTH.

Bradley, T. and I. and Sons, Darlaston.. Stacks, 1. Capacity, 30,000 tons per year. Fuel, coke. Ore, Spanish, Northamptonshire, Forest of Dean, and Ironworks Scoria. Brands, "<> <>" and "I. X. L."

	No. 1 <> <>	No. 2 <> <>	No. 4 <> <>
Silicon	3.600	3.200	2.05
Phosphorus	1.580	1.590	1.54
Sulphur	.041	.057	.06
Manganese	.900	.900	.89
Combined Carbon	.020	.100	....
Graphitic Carbon	3.360	3.240	....

Bradley, Thos. and Isaac, Ltd., Bilston. Brand, "Three Bands" (round pigs).

Could not obtain analysis of this iron.

Earl of Dudley, The—Brierley Hill. Brands, "L N F" (cold blast), "L N F—D U D," "L N F—XX" and "Coneygree."

Could not obtain analysis of this iron.

Grazebrook, M. and W., Netherton Iron Works, Dudley. Capacity, 6766 tons per year. Fuel, S. Staffs. thick coal, open hearth coked. Brands, "Grazebrook" (cold blast) and "Chilbrook."

For analysis of this iron, see Vol. I, p. 121.

Hickman, Alfred, Ltd., Bilston. Spring Vale Furnaces. Stacks, 5. Total capacity, 150,000 tons per year. Fuel, coke and coal. Ore, Hematite, Oolite. Brand, "S. V. H."

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicon	2.58	2.50	2.50	1.59	1.32
Phosphorus	.82	.82	.80	.75	.75
Sulphur	.02	.02	.04	.06	.07
Manganese	1.00	1.00	.95	.96	.87
Combined Carbon	trace	trace	trace	.08	.10
Graphitic Carbon	3.72	3.70	3.50	3.02	3.00

Hingley, N. and Sons, Ltd., near Dudley. Brand, "Old Hill."

Could not obtain analysis of this iron.

Pearson, Joseph H., Netherton Furnaces, East Worcestershire. Capacity, 22,000 tons per year. Fuel, native thick coal and S. Wales coke. Brands, "Netherton" (part mine) and "Windmill End" (cinder).

Could not obtain analysis of this iron.

STAFFORDSHIRE, SOUTH (Continued)

Roberts, Wm. (Tipton), Ltd., Tipton. Stacks, 3, one kept idle. Total capacity, 62,400 tons per year. Fuel, hard coke. Ore, Northampton Oolite and Forge (or "tap") cinders. Brand, "Roberts Tipton Green" (basic).

	No. 5.
Silicon	.80 and under
Phosphorus	2.50 and over
Sulphur	.08 and under
Manganese	1.50 and over
Combined Carbon / Graphitic Carbon	3.00 about

Russell, John and Company, Ltd., Walsall. Brand, "B. Mine."

Furnaces out of blast, being reconstructed on most modern lines.

Thomas, George and Richard, Bloxwich, near Walsall. Brands, "G. & R. T. Spécial," "Hatherton" and "Wall End."

Could not obtain analysis of this iron.

Whitehouse, H. B. and Son, Ltd., Bilston. Brands, "Priorfield" and "Walbrook."

Could not obtain analysis of this iron.

Williams, Philip and Sons, Wednesbury Oak Works, Tipton. Capacity, 7,500 tons per year. Fuel, coke. Brand, "W. O." (cold blast.)

For analysis of this iron, see Vol. 1, p. 122.

Willingsworth Iron Company, The—Wednesbury. Capacity, 20,000 tons per year. Fuel, local coal, S. Wales and Yorkshire coke. Brand, "Willingsworth."

For analysis of this iron, see Vol. I, p. 122.

WILTSHIRE.

Westbury Iron Company, Ltd., Westbury. Brand, "Westbury."

Could not obtain analysis of this iron.

WORCESTERSHIRE.

Cochrane and Company, Dudley. Stacks, 2. Fuel, coke and coal. Ore, clay ironstone and red. Brand, "Woodside."

	No. 4.
Silicon	1.218
Phosphorus	.419
Sulphur	.123
Manganese	.828
Combined Carbon / Graphitic Carbon	3.046

YORKSHIRE.

Bolckow, Vaughan and Company, Ltd., Middlesbrough. Fuel, coke. Brands, "B-V," "S. B. Yorkshire," "Cleveland," "Lackenby" and "Clay Lane."

	B-V			Cleveland	Clay Lane	
	No. 1.	No. 2.	No. 3.	No. 3.	No. 3.	White.
Silicon	3.00	2.80	2.60	3.33	3.21	1.300
Phosphorus	.05	.05	.05	1.51	1.52	1.530
Sulphur	.03	.05	.06	.05	.05	.045
Manganese	1.00	.95	.95	.70	.49	.300
Combined Carbon	.10	.15	.20	.10	.18	2.900
Graphitic Carbon	3.00	3.30	3.25	3.37	3.24	.100

YORKSHIRE (Continued)

BOLCKOW, VAUGHAN AND COMPANY, LTD.

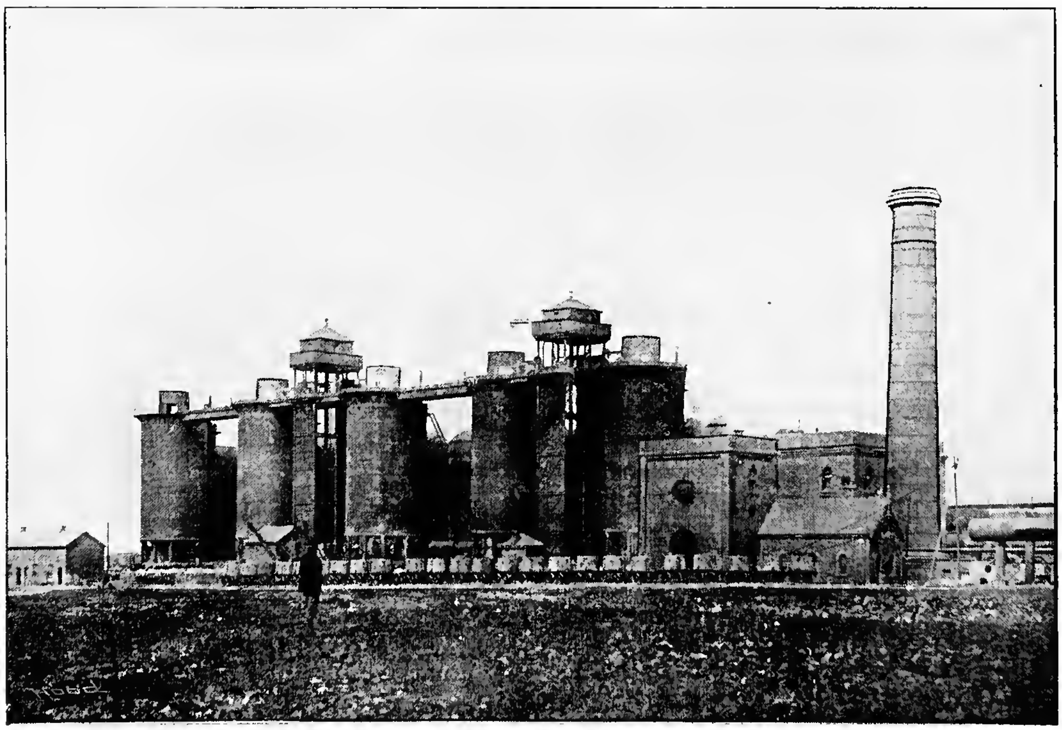
YORKSHIRE (Continued)

Brown, John and Company, Ltd., Sheffield. Capacity, 700 tons per week. Brand, "Atlas."

Could not obtain analysis of this iron.

Cargo Fleet Iron Company, Ltd., Middlesbrough. Stacks, 5. Total capacity, 130,000 tons per year. Fuel, Durham coke. Ore, Cleveland, with admixture of Swedish. Brand, "Cargo Fleet."

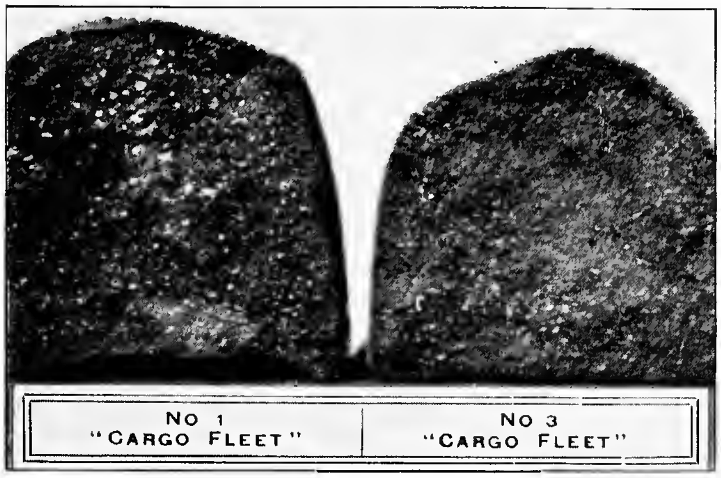
Approximate.	No. 1.	No. 2.	No. 3.	No. 4.	White.
Silicon	3.44		2.54	2.20	.79
Phosphorus	1.55	Do not	1.60	1.50	1.52
Sulphur	.04	now	.02	.04	.27
Manganese	.69	select	.66	.52	.23
Combined Carbon.	.66	No. 2	.13	.28	3.02
Graphitic Carbon.	2.98		3.55	3.49	.10

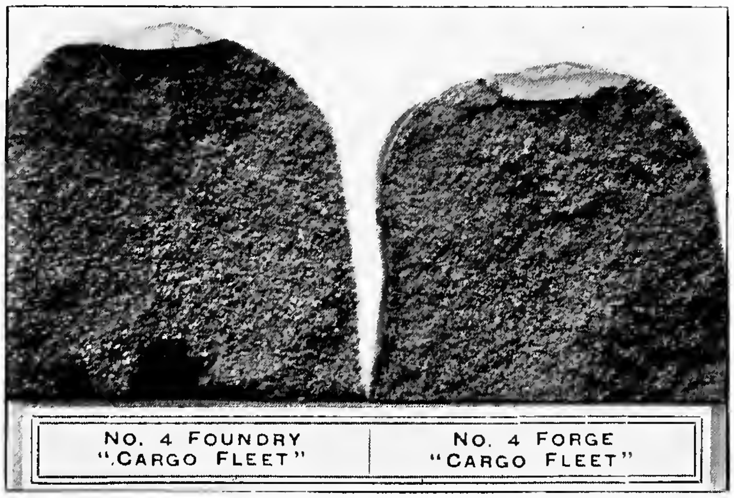


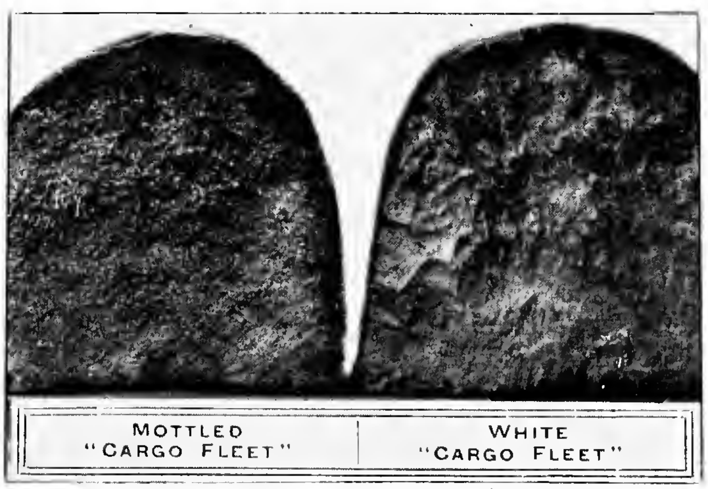
CARGO FLEET FURNACES.

YORKSHIRE (Continued)

CARGO FLEET IRON COMPANY, LTD.







YORKSHIRE (Continued)

Cochrane and Company, Ltd., Middlesbrough. Brand, "Ormesby."

Approximate.	No. 3.
Silicon	2.240
Phosphorus	1.483
Sulphur	.075
Manganese	.504
Combined Carbon	.177
Graphitic Carbon	3.334

Cooke, William and Company, Ltd., Sheffield. Brand, "Tinsley."

This company's output is all used by themselves for the manufacture of bar iron.

Farnley Iron Company, Ltd., The—Leeds. Stacks, 2. Total capacity, 10,000 tons per year. Fuel, coke, made from non-sulphurous coal. Ore, Clayband ironstone, 33 per cent iron. Brand, "Farnley" (cold blast only.)

	No. 5.
Silicon	1.03
Phosphorus	trace
Sulphur	.09
Manganese	.46
Combined Carbon	.29
Graphitic Carbon	3.12

For full particulars of the peculiar industry carried on here, see "Cassier's Magazine" of July, 1900.

Gjers, Mills and Company, Middlesbrough. Brands, "Ayrsome" (Cleveland), "H—Ayrsome—H" (hematite), "FS—Ayrsome—FS" (ferro silicon), and "SS—Ayrsome—SS" (Silico spiegel).

Approximate	No. 3 Hematite.	"Ayrsome" (Cleveland).
Silicon	2.00 to 2.50	3.100
Phosphorus	.04 to .05	.508
Sulphur	.05 to .07	.010
Manganese	1.32	.991
Combined Carbon	.64	.592
Graphitic Carbon	3.12	2.900

Leeds Steel Works, Ltd., The—Hunslet, Leeds. Capacity, 105,000 tons per year. Fuel, Durham and Yorkshire cokes. Brand, "L. S. W." (Bessemer basic pig iron.)

For analysis of this iron, see Vol. I, p. 126.

Lowmoor Company, Ltd., Bradford. Brand, "Lowmoor" (cold blast.)

Could not obtain analysis of this iron.

YORKSHIRE (Continued)

Newton, Chambers and Company, Ltd., Thorncliffe Iron Works, near Sheffield. Stacks, 2. Total capacity, 25,000 tons per year. Fuel, best hard furnace coke. Ore, Clayband, best Cumberland hematite and Leicestershire. Brand, "Thorncliffe." Product, iron suitable for all kinds of engineers' castings, is of great fluidity, strength and purity. No cinder has ever been used at these works.

	No. 1 Foundry.	No. 3 Foundry.
Silicon	2.950	2.65
Phosphorus	1.100	1.07
Sulphur	.004	.01
Manganese	.640	.54
Combined Carbon	traces	.49
Graphitic Carbon	3.750	3.49

THORNCLIFFE IRON WORKS.

YORKSHIRE (Continued)

NEWTON, CHAMBERS AND COMPANY, LTD.

No. 1 FOUNDRY THORNCLIFFE.

YORKSHIRE (Continued)

NEWTON, CHAMBERS AND COMPANY, LTD.

No. 3 FOUNDRY THORNCLIFFE.

YORKSHIRE (Continued)

Normanby Iron Works Company, Ltd., The—Middlesbrough. Stacks, 4. Total capacity, about 120,000 tons per year. Ore, largely best Rubio. Brand, "N. H. H." (hematite.)

	No. 1.	No. 2.	No. 3.	No. 4.	Mottled.	White.
Silicon	3.000	2.750	2.500	2.000	1.300	.900
Phosphorus	.045	.045	.045	.045	.045	.045
Sulphur	.030	.040	.060	.100	.300	.500
Manganese	1.000	.900	.800	.700	.500	.400
Combined Carbon	.200	.350	.350	.750	1.400	3.300
Graphitic Carbon	3.750	3.500	3.200	2.800	1.900	trace

NOTE.—Also makers of Normanby granulated slag and Normanby slag manure.

North Eastern Steel Company, Ltd., Middlesbrough. Brands, "Acklam Yorkshire" and "Acklam Basic."

Could not obtain analysis of this iron.

Park Gate Iron and Steel Company, Ltd., The—Rotherham. Brand, "P. G. Yorkshire."

This firm consumes themselves all pig iron they manufacture.

Samuelson, Sir B. and Company, Ltd., Middlesbrough. Brands, "B. S. Newport," "B. S. Hematite" and "B. S. Basic."

Approximate.	No. 3 B. S. Newport.
Silicon	2.75
Phosphorus	1.50
Sulphur	.04
Manganese	.50
Combined Carbon / Graphitic Carbon	3.50

Skinningrove Iron Company, Ltd., Saltburn-by-the-Sea. Brand, "Skinningrove."

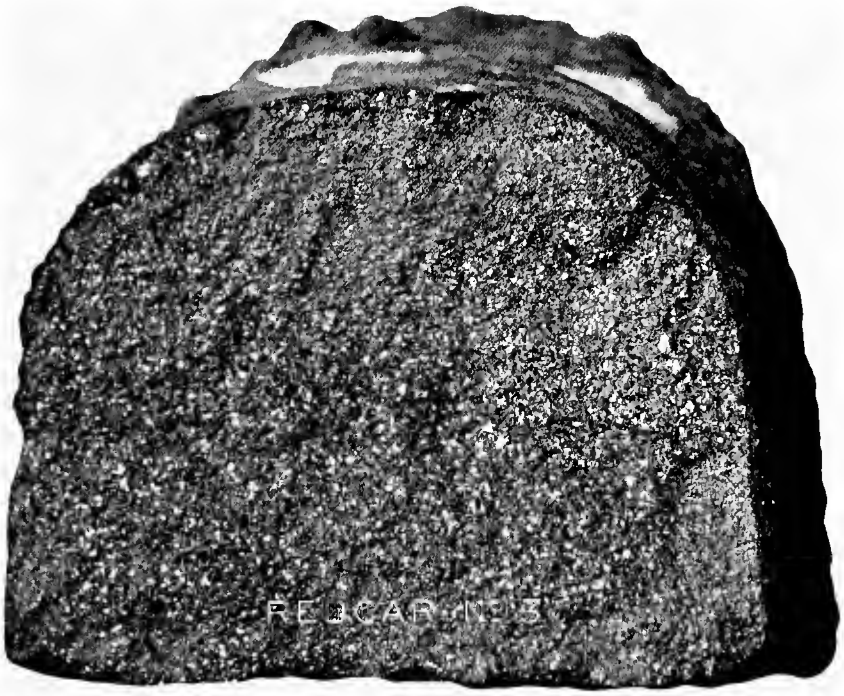
For analysis of this iron, see Vol. I, p. 127.

Walker, Maynard and Company, Redcar. Brand, "Redcar."

	Analyses of four samples No. 3 Iron.			
Silicon	2.67	2.67	2.48	2.61
Phosphorus	....	1.65	1.68	1.67
Sulphur	.03	.02	.05	.04
Manganese	.74	.76	....	.80
Combined Carbon	.14	.14	.24	.22
Graphitic Carbon	....	....	....	....

YORKSHIRE (Continued)

WALKER, MAYNARD AND COMPANY.



REDCAR NO. 3.

YORKSHIRE (Continued)

West Yorkshire Iron and Coal Company, Ltd., Ardsley Junc., Leeds. Brand, "Leeds."

Could not obtain analysis of this iron.

Williams, Edward—Linthorpe Iron Works, Middlesbrough. Brands, "E. W. Hematite" (bessemer) and "Linthorpe" (Cleveland).

Could not obtain analysis of this iron.

Wilsons, Pease and Company, Ltd., Middlesbrough. Brand, "G. W. L."

Approximate.	No. 3.
Silicon	2.89
Phosphorus	1.55
Sulphur	.01
Manganese	.69
Combined Carbon	.11
Graphitic Carbon	3.69

York Road Iron Company, The—Leeds. Cold blast pig iron.

This company's output is all used by themselves.

SCOTLAND

AYRSHIRE.

Baird, William and Company, Ltd., Kilwinning. Fuel, raw coal. Brand, "Eglinton."

For analysis of this iron, see Vol. I, p. 131.

AYRSHIRE (Continued)

Dalmellington Iron Company, Ltd., Dalmellington (by Ayr). Brand, "Dalmellington."

For analysis of this iron, see Vol. I, p. 131.

Glengarnock Iron and Steel Company, Ltd., The—Glengarnock and Stevenston. Stacks, 12. Total capacity, 200,000 tons per year. Fuel, Splint coal. Ores, Blackband and Clayband ironstones (coal measures) and Spanish hematite. Brand, "Glengarnock."

	No. 1.	No. 3.
Silicon	3.50	2.50
Phosphorus	.55	.55
Sulphur	.03	.04
Manganese	1.25	1.18
Combined Carbon	.26	.40
Graphitic Carbon	3.30	3.10

LANARKSHIRE.

Baird, Wm. and Company, Ltd., Coatbridge. Fuel, raw coal. Brand, "Gartsherrie."

For analysis of this iron, see Vol. I, p. 131.

Coltness Iron Company, Ltd., Newmains, N. B. Brand, "Coltness."

For analysis of this iron, see Vol. I, p. 133.

Dixon, Wm., Ltd., Coatbridge and Glasgow. Brands, "Calder," "Govan" and "Govan Hematite."

Could not obtain analysis of this iron.

Dunlop, James and Company, Ltd., Tolcross, near Glasgow. Brand, "Clyde."

For analysis of this iron, see Vol. I, p. 133.

Glasgow Iron and Steel Company, Ltd., The—Wishaw. Brand, "Wishaw."

Hematite.	No. 1.	No. 2.	No. 3.
Silicon	2.980	2.800	2.660
Phosphorus	.038	.042	.042
Sulphur	.020	.033	.035
Manganese	1.300	1.250	1.080
Combined Carbon	.380	.460	.480
Graphitic Carbon	3.250	2.800	2.660

LANARKSHIRE (Continued)

Langloan Iron and Chemical Company, Ltd., Coatbridge. Brand, "Langloan."

For analysis of this iron, see Vol. I, p. 133.

Merry and Cuninghame, Ltd., Coatbridge. Brands, "Carnbroe" and "M. and C."

	Carnbroe	
	No. 1.	No. 3.
Silicon	3.700	2.820
Phosphorus	1.160	1.060
Sulphur	.042	.048
Manganese	1.100	1.390
Combined Carbon....	.084	.400
Graphitic Carbon.....	3.750	3.450

Shotts Iron Company, Shotts. Brand, "Shotts."

For analysis of this iron, see Vol. I, p. 134.

Summerlee and Mossend Iron and Steel Company, Ltd., The—Coatbridge. Ore, Scotch Blackband ironstone. Brand, "Summerlee."

For analysis of this iron, see Vol. I, p. 134.

STIRLINGSHIRE.

Carron Company, Carron, N. B. Fuel, coke. Ore, Scotch Blackband ironstone. Brand, "Carron."

For analysis of this iron, see Vol. I, p. 134.

WALES

CARMARTHENSHIRE.

Anthracite Iron and Steel Company, Ltd., near Kidwelly.

Could not obtain analysis of this iron.

DENBIGHSHIRE.

Brymbo Steel Company, Ltd., Brymbo, Wrexham. Brand, "Brymbo."

Could not obtain analysis of this iron.

Sparrow, Jas. and Son, near Wrexham. Fuel, coal. Capacity, 17,500 tons per year. Brand, "Ffrwd" (all mine.)

For analysis of this iron, see Vol. I, p. 137.

FLINTSHIRE.

Darwen and Mostyn Iron Company, Ltd., Mostyn. Brands, "Darwen" and "Mostyn."

Could not obtain analysis of this iron.

GLAMORGANSHIRE.

Briton Ferry Works, Ltd., Briton Ferry. Brand, "Ferry."

Could not obtain analysis of this iron.

Cefn Iron Works, Ltd., The—Near Bridgend. Brand, "Mine."

Could not obtain analysis of this iron.

GLAMORGANSHIRE (Continued)

Crawshay Brothers, Cyfarthfa, Ltd., Merthyr Tydfil. Brand, "Crawshay."

For analysis of this iron, see Vol. I, p. 138.

Guest, Keen and Company, Ltd., Dowlais. Brands, "Dowlais" and "Dowlais Cardiff."

Could not obtain analysis of this iron.

Pyle and Blaina Works, Ltd., Pyle, near Bridgend. Brand, "Star."

Could not obtain analysis of this iron.

Wright, Butler and Company, Ltd., Landore. Stacks, 2. Total capacity, 293,000 tons per year. Fuel, coke. Ore, Spanish and Portuguese. Brand, "Swansea Hematite."

	No. 1.	No. 2.	No. 3.
Silicon	3.00	2.700	2.300
Phosphorus	.04	.042	.045
Sulphur	.01	.022	.040
Manganese	.97	.900	.890
Combined Carbon	.08	.180	.300
Graphitic Carbon	4.15	3.900	3.500

Wright, Butler and Company, Ltd., Cwm Avon. Brand, "Cwm Avon."

These furnaces have been idle some time, consequently could furnish no analysis.

BELGIUM

Acoz, Blast Furnaces of—Bouffioulx, Hainaut.

Angleur, Steel Works of—Tilleur, Liége.

Grivegnée Iron Works, Grivegnée, Liége.
For analysis of iron made at these furnaces, see Vol. I, p. 141.

Hourpes sur Sambre Iron Works, Thuin. Hainaut.

La Louvière, Blast Furnaces and Smelting Works of—La Louvière, Hainaut.

L' Espérance Longdoz Iron Works, Seraing, Liége.

Monceau sur Sambre Iron Works, Monceau sur Sambre, Hainaut.
For analysis of iron made at these furnaces, see Vol. I, p. 142.

Musson Company, Ltd., Blast Furnaces, Foundries and Mines of—Musson, Province of Luxembourg.

Providence Iron Works, Marchienne-au-Pont, Hainaut.

South Châtelineau, Blast Furnaces of—Châtelineau, Hainaut.

Thy le Château, Blast Furnaces and Steel Works of—Marcinelle, Hainaut.
For analysis of iron made at these furnaces, see Vol. I, p. 143.

Athus, Blast Furnaces of—Athus, Province of Luxembourg. Stacks, 2. Total capacity, 80,000 tons per year. Fuel, coke. Ore, Oolitic from the Grand Duchy of Luxembourg. Brand, "Athus."

	No. 3
Silicon	2.90
Phosphorus	1.85
Sulphur	.05
Manganese	.35
Total Carbon	3.25

BELGIUM (Continued)

Blast Furnaces of the Society John Cockerill, Seraing, Liége. Stacks, 5. Total capacity, 172,000 tons per year. Fuel, coke and anthracite. Ores from Spain, Algeria, Greece, Sweden, Germany, Grand Duchy of Luxembourg, France, Belgium and sundry refuse.

Bessemer Iron.

Silicon	1.00 to 2.50
Phosphorus	.05
Sulphur	trace to .05
Manganese	1.00 to 1.50
Combined Carbon	.40
Graphitic Carbon	3.15

Couillet Iron Works, Couillet and Châtelineau, Hainaut. Stacks, 2 each. Total capacity, 87,000 tons per year. Fuel, coke. Ores, crushed ores from Luxembourg, ores from Campine, clinkers from rolling mills and manganese ores from different countries.

Analyses of Irons Made at Couillet.

	No. 3	No. 4	No. 5
Silicon	2.00 to 3.80	2.510	2.190
Phosphorus	1.85 to 1.90	1.75 to 1.90	1.75 to 1.90
Sulphur	.03 to .07	.039	.056
Manganese	.30 to .40	.30 to .40	.30 to .40
Combined Carbon	.19	.190	.300
Carbon	3.15 to 3.30	3.370	3.150

Ougrée Iron Works, Ougrée, Liége. Stacks, 3. Total capacity, 150,000 tons per year. Fuel, coke.

Silicon	.20 to .60
Phosphorus	2.10
Sulphur	.04
Manganese	1.80
Carbon	2.80
Graphite	.50

BELGIUM (Continued)

BLAST FURNACES OF HALANZY.

Halanzy, Blast Furnaces of—Halanzy, Province of Luxembourg. Stacks, 2. Total capacity, 45,000 tons per year. Fuel, coke. Ores, Oolitic from the Grand Duchy of Luxembourg.

Special Quality Foundry Iron.

	No. 1	No. 2	No. 3	No. 4	No. 5
Silicon	3.160	3.120	3.020	2.890	2.780
Phosphorus	1.250	1.250	1.260	1.280	1.330
Sulphur	.004	.005	.007	.010	.012
Manganese	.620	.590	.540	.510	.490
Combined Carbon	.150	.170	.200	.260	.330
Graphitic Carbon	3.670	3.480	3.300	3.120	2.890
Total Carbon	3.820	3.650	3.500	3.380	3.220

Ordinary Foundry Iron for Shipment.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Silicon	2.850	2.700	2.500	2.200	1.900	1.650	1.500
Phosphorus	1.550	1.530	1.510	1.500	1.490	1.470	1.460
Sulphur	.005	.005	.006	.008	.011	.024	.031
Manganese	.650	.620	.570	.530	.500	.460	.410
Combined Carbon	.170	.200	.290	.330	.350	.380	.400
Graphitic Carbon	3.530	3.350	3.140	2.970	2.800	2.670	2.550
Total Carbon	3.700	3.550	3.430	3.300	3.150	3.050	2.950

Special Silicious Irons for Mixtures.

Ferro-Silicon	3.50 to 8.00
Phosphorus	....
Sulphur	none
Manganese	....
Combined Carbon	....
Graphitic Carbon	....

Refined Irons.

	Grey	Trout Colored Grey	Trout Colored White	White
Silicon	1.350	1.050	.800	.510
Phosphorus	1.500	1.540	1.580	1.630
Sulphur	.060	.096	.071	.283
Manganese	.350	.300	.200	.150
Combined Carbon	.450	1.300	2.450	2.700
Graphitic Carbon	2.450	1.550	.300	traces
Total Carbon	2.900	2.850	2.750	2.700

CANADA

NOVA SCOTIA.

Dominion Iron and Steel Company, Ltd., Sydney, Cape Breton County. Stacks, 4. Total capacity, 450,000 tons per year. Fuel, coke. Ores, local and Newfoundland. Product, foundry, forge and basic irons, cast in either sand or chilled moulds.

This company adjusts the analysis to the many diff rent requirements of customers.

Londonderry Iron Company, Ltd., The—Acadia Iron Mines (near Londonderry), Colchester County. Stacks, 2. Total capacity, 40,000 tons per year. Fuel, coke. Ores, limonite, carbonate and red hematite.

Could not obtain analysis of this iron, as furnace has been out of blast since 1897.

Nova Scotia Steel and Coal Company, Ltd., Ferrona, Pictou County. Stacks, 1. Capacity, 32,000 tons per year. Fuel, coke. Ores, local brown and red hematite and Newfoundland. Brand, "Ferrona."

For analysis of this iron, see Vol. I, p. 147.

Pictou Charcoal Iron Company, Ltd., Bridgeville, Pictou County. Bridgeville Furnace. Stacks, 1. Capacity, 7,300 tons per year. Fuel, coke and charcoal. Ores, iron and manganese. Product, ferro-manganese.

ONTARIO.

Algoma Steel Company, Ltd., The—Sault Ste. Marie, Algoma District. Stacks, 4,—two charcoal and two coke. Total capacity, 100,000 tons charcoal iron, 280,000 tons coke iron per year. Ore, hematite. Brand, "Algoma."

Could not obtain analysis, as furnaces will not be producing until 1903.

Canada Iron Furnace Company, Ltd., Midland, Simcoe County. Stacks, 1. Capacity, 45,000 tons per year. Fuel, coke. Ore, Michipicoten. Brand, "Midland." Product, foundry iron, so varied in order to fill contracts for various classes, that we were unable to obtain analysis just at present.

ONTARIO (Continued)

Cramp Steel Company, Ltd., The—Collingwood, Simcoe County. Stacks, 2. Total capacity, 180,000 tons per year. Fuel, coke. Ore, Canadian hematite and magnetic. Product, bessemer iron.

Deseronto Iron Company, Ltd., Deseronto, Hastings County. Deseronto Furnace. Stacks, 1. Capacity, 11,000 tons per year. Fuel, charcoal. Ores, Lake Superior and local. Brand, "Deseronto."

Grading Card.

Silicon.

Grades	Average %	Variation %	Chill Test
Scotch	All	above 2.00	
No. 1 A	1.85	1.70 to 2.00	
No. 1 B	1.60	1.50 to 1.70	
No. 2 Soft	1.35	1.20 to 1.50	
No. 2 Regular	1.05	.90 to 1.20	
No. 2 Hard	.82	.75 to .90	
No. 3 Low	.67	.60 to .75	
No. 3 High	.62	.55 to .70	Chill ½ inch
No. 4 Low	.45	.40 to .50	Chill 1 inch
No. 4½	.35	.30 to .40	Chill 1½ inch
No. 4 High	.32	.25 to .40	Chill 1¾ inch
....	....	....	and Top and Bottom of Pig
No. 5 Low	.25	.20 to .30	Low Mottled
No. 5 High	.15	.10 to .20	High Mottled
No. 6	.07	.00 to .15	White

Phosphorus	.15 to .230
Manganese	.25 to .500
Sulphur	trace to .016

Nos. 3, 4, 5 and 6 are graded by chill test. Other grades by silicon analysis.

Hamilton Steel and Iron Company, Ltd., The—Hamilton, Wentworth County. Hamilton Furnace. Stacks, 1. Capacity, 65,000 tons per year. Fuel, Reynoldsville, Soldier Run coke. Ores, hematite. Brand, "Hamilton." Product, foundry and basic irons.

	No. 1	No. 2
Silicon	2.25 to 3.00	2.00 to 2.25
Phosphorus	.45 to .70	.45 to .70
Sulphur	.02	.04
Manganese	.60 to .75	.60 to .75
Combined Carbon	.25	.35
Graphitic Carbon	3.50	3.20

QUEBEC

Canada Iron Furnace Company, Ltd., Radnor, Champlain County. Stacks, 1. Capacity, 10,000 tons per year. Fuel, charcoal. Ores, lake and bog. Brand, "C. I. F." Product, iron for car wheels, chilled rolls, etc.

Could not obtain analysis of this iron (see Ontario).

McDougall, John and Company, Drummondville, Drummond County. Stacks, 2. Total capacity, 2,400 tons per year. Fuel, charcoal (cold blast). Ore, bog. Brand, "Drummondville." Product, car wheel iron.

	No. 3
Silicon	1.200
Phosphorus	.900
Sulphur	.030
Manganese	....
Combined Carbon	....
Graphitic Carbon	2.970

FRANCE

We have been able to secure in addition to the average analysis of French irons, published in Vol. I, p. 151, that of "Senelle" iron, made by the Société Senelle, Maubeuge, Longwy.

Foundry Iron.

Average	No. 1	No. 2	No. 3	No. 4	No. 5
Silicon	3.150	3.090	2.940	2.510	2.190
Phosphorus	1.75 to 1.90	1.75 to 1.90	1.75 to 1.90	1.75 to 1.90	1.75 to 1.90
Sulphur	.012	.010	.031	.039	.056
Manganese	.30 to .40	.30 to .40	.30 to .40	.30 to .40	.30 to .40
Combined Carbon.	.200	.230	.190	.190	.300
Total Carbon.....	3.750	3.550	3.400	3.370	3.150

The No. 3 iron varies in composition as follows:

Silicon	2.00 to 3.00
Phosphorus	1.70 to 1.90
Sulphur	.03 to .07
Manganese	.30 to .40
Combined Carbon......	.25 to .40
Graphitic Carbon..	2.95 to 3.00
Total Carbon.....	3.20 to 3.40

FRANCE (Continued)

SOCIÉTÉ SENELLE.

GERMANY

In our first volume, we were able only to publish approximate analyses of standard grades of German pig iron, but for this book we were more successful in that we secured some analyses direct from the makers, which are reproduced herewith.

Lothringisch-Luxemburgisches Comptoir fur Verkauf von Roheisen (syndicate), consisting of following firms:

Metz and Company, Eich, Luxemburg.

Les petits fils de François de Wendel, Hayange, Lothringen.

Société anonyme des Hauts Fourneaux d'Audun le Tiche, Deutsch-Oth, Lothringen.

Société anonyme des Hauts Fourneaux de Rodange, Rodange, Luxemburg.

Société anonyme des Hauts Fourneaux de Rumelange, Rümelingen, Luxemburg.

Differdinger Hochofen Act. Ges., Differdingen, Luxemburg.

C. and J. Collart, Steinfort, Luxemburg.

Rombacher Hüttenwerke, Rombach, Lothringen.

Lothringer Hüttenverein Friedenshütte, Kneuttingen.

Fuel, coke. Ore, Luxemburg Minette.

	Foundry Pig Iron No. 3	No. 4	No. 5
Silicon .... About	2.71	2.42	2.280
Phosphorus ... About	1.72	1.76	1.750
Sulphur .... About	.01	.02	.028
Manganese .... About	.59	.59	.590
Carbon .... About	3.63	3.47	3.420

Birlenbacher Huttengewerkschaft, Schleifenbaum and Company. Birlenbacherhütte bei Geisweid, Kreis Siegen, Westfalen. Stacks, 1. Capacity, about 9,000 tons per year. Fuel, coke. Ores, Siegerland and Nassau ironstone.

	White	Grey Forge
Silicon	.6342	.6234
Phosphorus	.0655	.0765
Sulphur	.....	.....
Manganese	4.8081	3.7585

Eiserfelder Huttengewerkschaft, Eiserfeld, near Siegen, Westfalen. Stacks, 1. Annual capacity, 22,000 tons. Fuel, coke. Ore, spathite, brown and red.

	White	Grey Forge	Mottled	Bessemer	Low Phosphorus	Spiegeleisen
Silicon	.10	.20	.15	2.00–3.00	.10	.10
Phosphorus ...	.15	.20	.15	.15	.06	.08
Sulphur	.05	.05	.05	.06	.05	.04
Manganese ...	4.00	3.00	3.00–4.00	2.00–3.00	5.00	6.00–12.00
Carbon	4.00	4.00	4.00	3.00–4.00	4.00	4.00– 5.00

GERMANY (Continued)

Friedrich-Wilhelms-Hütte, Mülheim a. d. Ruhr. Stacks, 3. Total annual capacity, 100,000 tons. Fuel, Ruhr coke. Ore, Spanish, Grecian, Algerian, Luxemburg and Lorraine.

	Foundry Irons.		
	No. 1	No. 3	Hematite
Silicon	3.250	2.720	3.170
Phosphorus	.670	.710	.084
Sulphur	.020	.023	.021
Manganese	.760	.780	.930
Combined Carbon	.320	.370	.270
Graphitic Carbon	3.490	3.340	3.580

Hoerder Bergwerks-und Hüttenverein, Hoerde, Westfalen. Fuel, coke.

	Thomas	Low Phosphorus
Silicon	.30	.12
Phosphorus	1.90	.15
Sulphur	.07	.04
Manganese	1.20	2.80
Carbon	2.60	3.30

NOTE.—All pig iron made by this firm is used in their own manufacture.

Königl. Hütte. Gleiwitz, o./Schl. Stacks, 1. Capacity, 24,000 tons per year. Fuel, coke. Ores, Silesia, Polish, Hungarian and Swedish.

		Foundry			
	No. 1	No. 2	No. 3	White	Grey Forge
Silicon	4.50	3.50	3.00	.70	1.50
Phosphorus	.50	.60	.70	.50	.60
Sulphur	.03	.04	.05	.05	.07
Manganese	1.40	1.30	1.20	2.50	1.80
Carbon	3.70	3.50	3.30	3.30	3.10

Eisenwerk Kraft at Kratzwieck, near Stettin. Stacks, 3. Total annual capacity, about 120,000 tons per year. Fuel, coke. Ore, Swedish and Spanish. Brand, "Kraft."

	No. 1 Hematite	No. 1 Foundry
Silicon	3.500	3.140
Phosphorus	.056	.350
Sulphur	.030	.027
Manganese	.880	Below 1.000
Combined Carbon. / Graphitic Carbon.	About 4.000	About 4.000

GERMANY (Continued)

Luxemburger Bergwerks und Saarbrücker Eisenhütten, Act. Ges. Burbacherhütte bei Saarbrücken. Stacks, 6. Total annual capacity, 270,000 tons. Fuel, coke. Ore, Lorraine and Luxemburg Minette.

This company makes only Thomas pig iron.

Silicon	.550
Phosphorus	2.010
Sulphur	.082
Manganese	1.497
Carbon	3.500

Oberschlesische Eisen-Industrie, Act. Ges. für Bergbau und Hüttenbetrieb. Hochofenwerk Julienhütte, Bobrek, o./Schles. Capacity, 100,000 to 150,000 tons per year. Fuel, coke. Ore, Upper Silesia brown, Swedish and Hungarian. Brand, "Julienhutte."

	No. 1 Foundry	White	Grey Forge	Mottled
Silicon	2.50–3.50	.40– .80	1.50–2.00	1.00–1.50
Phosphorus	.20– .40	.20– .60	.20– .60	.20– .60
Sulphur	.02– .04	.03– .08	.02– .06	.03– .07
Manganese	1.00–1.50	2.00–3.50	2.00–3.50	2.00–3.50
Carbon	about 3.50	3.20–3.80	about 3.50	about 3.50

Rheinische Bergbau und Hüttenwesen Act. Ges. (Neiderrheinische Hütte) Duisburg-Hochfeld. Stacks, 4. Total annual capacity, 120,000 to 150,000 tons. Fuel, coke. Ores, four-fifths foreign, one-fifth from the Lahn.

	Foundry			Grey		Hematite			
	No. 1.	No. 3.	White.	Forge.	Mottled.	No. 1.	No. 3.	Ferro-Silicon.	Thomas.
Silicon	2.50–3.50	2.00–2.50	.20– .60	1.50	1.00	2.50–3.50	2.00–2.50	10.00–17.00	.20– .60
Phosphorus	.30– .50	.30– .50	.30–	.30	.30	.08	.08	.07	2.00
Sulphur	trace	trace	.03– .05	.03	.03	trace	trace	trace	.10 max.
Manganese	.80–1.00	.80–1.00	2.50–4.00	1.00	1.00	.80–1.00	.80–1.00	.75– 1.00	2.50–3.00
Combined Carbon. Graphitic Carbon.	3.80–4.00	3.80	3.80	3.80	3.80	4.00	3.80	....	3.50–3.80

SWEDEN

We have been unable to procure any further information from iron makers in this country other than a full list of the iron furnaces, given herewith.

For previous analyses, see Vol. 1, p. 172.

LIST OF IRON FURNACES.

Adelsfors Jernbruk, Braås.
Agegrufvans Masugn, Finshyttan.
Alexisfors Jernbruk, Jönköping.
Alters Bruk, Håkansö, Piteå.
Alkvetterns A. B., Alkvettern, Kristinehamn.
A. B. Ankarsrums Bruk, Ankarsrum.
Annefors Bruk, Fredriksberg.
Avesta Jernverks A. B., Avesta.
Axmars Jernverk, Bergby.
Baggå Jernbruk, Baggå.
Bennebo Masugn, Högfors.
Karbennings Masugn, Högfors.
Billsjö Masugn, Viksberg.
Björkhyttans Masugn, Svartå.
Björneborgs Jernverks A. B., Vermlands Björneborg.
Björsjö Masugn, Smedjebacken.
A. B. Bofors-Gullspång, Bofors.
Graningeverkens A. B., Bollstabruk.
Borgviks A. B., Borgvik.
Bosjö Hytta, Finnmossen.
Boxholms A. B., Boxholm.
A. B. Bredsjö Bruk, Bredsjö.
Brefvens Bruk, Kilsmo.
Bro Hytta, Storvik.
Bråfors Hytta, Norberg.
Svanå Bruks A. B., Nordansjö, Kärrgrufvan.
Dalkarlshytte A. B., Lindesberg.
Degerfors Jernverk, Degerfors, Örebro län.
Domnarfvets Jernbruk, Domnarfvet.
Garpenbergs A. B., Fors' Station.
Schebo Bruks A. B., Edsbro.
Klosters A. B., Edsken, Stjernsund.
Edsvalla Bruk, Edsvalla.
Elfbrons Masugn, Kristinehamn.
Elfvestorps A. B., Elfvestorp.
Fagersta Bruks A. B., Vestanfors.
Finnbo Masugn, Smedjebacken.
A. B. Finspongs Styckebruk, Finspong.
Forsbacka Jernv. A. B., Forsbacka.
Storfors Bruks A. B., Gammalkroppa.
Gimo Jernbruk, Gimo.
Gnarps Masugn, Gnarp.

Continued.

SWEDEN (Continued)

LIST OF IRON FURNACES—*Continued.*

Gonäs Masugn, Gonäs.
Granbergsdals Masugn, Granbergsdal.
Grythyttans Masugn, Grythyttehed.
Grönsinka Jernbruk, Horndal.
Guldsmedshytte A. B., Guldsmedshyttan.
Gusselhyttans Masugn, Gusselby.
Uddeholms A. B., Gustafsfors Bruk. Geijersholm.
Gysinge A. B., Gysinge.
Hagelsrums Masugn, Hagelsrum.
Söderfors Bruks A. B., Harnäs Masugn, Harnäs.
Hasselfors Bruks A. B., Hasselfors.
Bruttfors A. B., Hedenskogs Hytta, Filipstad.
Hellsjö Bruk, Grängesberg.
Hilleviks Bruk, Strömsbro.
A. B. Bredsjö Bruk, Hjulsjö nya hytta, Hjulsjö.
Hofors A. B., Hofors.
Horndals Jernverks A. B., Horndal.
Huseby Jernbruk, Vislanda.
Häryds Bruk, Gnosjö.
Högfors & Persbro A. B., Högfors.
Högfors A. B., Hörk.
Hörks Hytta & Masugn, Bergslags-Hörken.
A. B. Iggesunds Bruk, Iggesund.
Jädraås Masugn, Jädraås.
Kafveltorps A. B., Kopparberg.
Karlsdals A. B., Karlsdal.
Kilafors Jernverks A. B., Kilafors.
Klafreströms Bruk, Klafreström.
Klenshyttans Masugn, Klenshyttan.
Klotens A. B., Kloten.
Klunkhyttans Masugn, Hidingebro.
Korsnäs Masugn, Korsnäs.
Laxsjöns Bruk, Rämen.
Lenna Masugn, Lenna Station.
Lindesby Tackjernshytta, Jernboås.
Ljusmarsbergs Kopparverk, Kopparberg.
Ljusne Jernverk, Ljusne.
Ludvika Bruk, Ludvika.
Långbans Hytta, Långbanshyttan.
Långshyttans Jernbruk, Långshyttan.
Löa Masugns A. B., Rällså.
Marieholms Jernverks A. B., Klefshult.
Marnäs Masugn, Ludvika.
Mattsbo Masugn, Ramnäs Bruks A. B., Smedjebacken.
Movikens Masugn, Strömbacka.

Continued.

SWEDEN (Continued)

LIST OF IRON FURNACES—*Continued.*

Nordansjö Masugn, Kärrgrufvan.
Nordansjö Hytta, Svanå Bolag, Norberg.
Nordmarkshyttans Masugn, Finnmossen.
Norhyttans Masugn, Norhyttan.
Norns Masugn, Vikmanshyttan.
Nyhammars Bruks, A. B., Gransgärde.
Nykroppa Masugn, Nykroppa.
Näfveqvarns Bruk, Näfveqvarn.
Näs Masugn, Näs Station.
Olofsfors Jernbruk, Nordmaling.
Orrefors Bruks A. B., Orrefors.
Pershyttans Masugn, Pershyttan.
Qväggeshyttans Masugn, Kristinehamn.
Ramsbergs Jernbruk, Ramsberg.
Rasjö Masugn, Bondstorp.
Ringshytte Bolag, Striberg.
Robertsfors Jernbruk, Sikeå.
Röfors Masugn, Laxå.
A. B. Skisshyttan, Gräsberg.
A. B. Skogaholms Bruk, Svennevad.
Skrikarhyttans Masugn, Vikersvik.
Spännarehyttans Masugn, Kärrgrufvan.
Stafsjö Jernbruks A. B., Stafsjö.
Stens Jernbruk, Grafversfors.
Storbrons Hytta, Filipstad.
Storå Tackjernshytta, Vasselhyttan.
Strömsdals Masugn, Strömsdals Bruk.
A. B. Stjernfors-Ställdalen, Ställdalen.
Sundshyttans Masugn, Grythyttehed.
Sunnansjö Masugn, Sunnansjö.
Svartå Masugn, Elfsbacka.
Svartå Bruks A. B., Svartå.
Säfvenfors Hytta, Hellefors.
Söderfors Bruks A. B., Söderfors.
Torps Jernbruk, Moheda.
Trummelsbergs Masugn, Stjernvik.
Ulfshytte Jernv. A. B., Ulfshyttan.
Uttersbergs Bruks A. B., Uttersberg.
Valåsens Masugn, Valåsen.
Vekhyttans Masugn, Qvisbro.
Vestgöthyttans Tackjärnshytta, Gyttorp.
Vesterby Hytta, Söderbärke.
Ågs Masugn, Svärdsjö.
Åmmebergs Bruk, Åmmeberg.
A. B. Öfverums Bruk, Öfverum.
A. B. Österby Bruk, Dannemora.

MISCELLANEOUS

Not having received any individual analyses direct from furnaces, we have nothing new to add to that set forth in Vol 1, with reference to—

RUSSIA,

SPAIN,

JAPAN,

MEXICO,

and we have been unable to procure any information whatever as to the iron produced in

AUSTRIA.

A PRESENT FOR A BASE BALL FAN

If you are puzzled in the selection of a present for your friend who is interested in base ball, then the problem is easily solved: Give a copy of "HISTORY OF BASE BALL." Vol. I (1845-1871), by S. R. Church. The book is a large quarto, printed in the hest style of the art, upon the heaviest calendered paper, elegantly bound in pegamoid and gold, and profusely illustrated with black and white and full-page colored half tones. Price, $1.50, post-paid. Any hoy would be tickled half to death to receive a present of this kind, and many of the old boys will appreciate it just as much. Don't forget the lady fans. You could not give a more appropriate token of remembrance or affection.

FOR SALE BY

R. D. SCHELL,
147 East 125th St.,
New York, N. Y.

WRIGHT & DITSON,
344 Washington St.,
Boston, Mass.

A. J. REACH & CO.,
Tulip & Palmer Sts.
Philadelphia, Pa.

GEO. S. BOLSTERLE,
Plainfield, N. J.

A. G. SPALDING & BROS.,
126 Nassau St.,
New York, N. Y.

THE SPORTING NEWS,
810 Olive St.,
St. Louis, Mo.

RUBE WADDELL

PITCHER, LOS ANGELES BASE BALL CLUB, 1902

Order from S. R. CHURCH, 307 Sansome Street, San Francisco, California.

Price of this picture is 5 cents per copy, and is published by S. R. Church, 307 Sansome Street, San Francisco, who sells those Fresh Snowballs, the kind that do not melt, and Pig Iron, hard and soft. Analyses of Pig Iron, $5.00 per copy; also Base Ball Schedule and Memorandum Book, four volumes, 10 cents per volume. When ordering state which volume is wanted. Picture of George Wright and Golden Gate, 3 cents per copy.

WALES L. PALMER
PRESIDENT

JOHN W. BROWN
SUPERINTENDENT

WM. E. PALMER
SECRETARY

GOLDEN STATE AND MINERS' IRON WORKS

FOUNDRY AND MACHINE WORKS

BUILDERS OF MINING, MILLING AND DREDGING MACHINERY

DREDGERS FOR GOLD A SPECIALTY. MARINE WORK OF ALL CLASSES

231 TO 251 FIRST ST., SAN FRANCISCO, CAL

LOUIS DEROME, MANAGER

TELEPHONE MAIN 1271

Globe Brass and Bell Foundry

MANUFACTURERS OF

BRONZE STATUARY, CEMETERY WORK AND ART WORK

OF EVERY DESCRIPTION

ALUMINUM, MANGANESE AND PHOSPHOR BRONZE, COPPER, GUN METAL, BRASS, COMPOSITION, ZINC AND BABBITT METAL

CASTINGS

126-128 MAIN STREET, SAN FRANCISCO, CAL.

JOHN G. ILS & CO.

French Cooking Ranges and Broilers.

KITCHEN AND BAKERY OUTFITS.

814-816 KEARNY ST. San Francisco, Cal.

PHONE MAIN 1106

PROPRIETORS JACKSON FOUNDRY

Chas. C. Moore & Co.

ENGINEERS AND DEALERS

MOTIVE POWER MACHINERY OF THE HIGHEST GRADE

MODERN STEAM SPECIALTIES

The Babcock & Wilcox Co.

STATIONARY AND MARINE WATER TUBE BOILERS

HOME OFFICE, NEW YORK

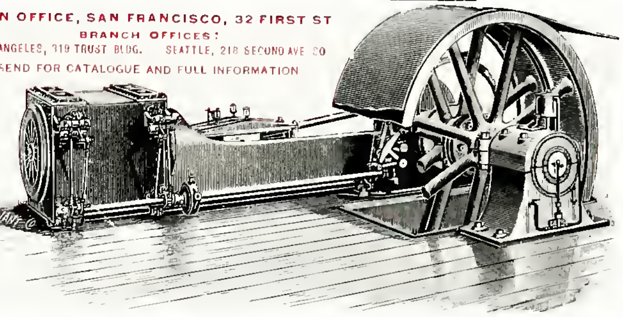
CHAS. C. MOORE, MGR. PACIFIC COAST BRANCH

MAIN OFFICE, SAN FRANCISCO, 32 FIRST ST

BRANCH OFFICES:

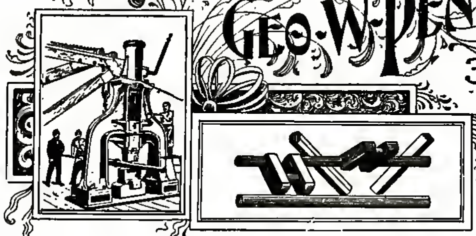
LOS ANGELES, 319 TRUST BLDG. SEATTLE, 218 SECOND AVE. SO

SEND FOR CATALOGUE AND FULL INFORMATION



GEO. W. PENNINGTON SONS INC.

313 Folsom St.



Best Refined Tool Steel.
Drill & Chisel Steel, Wedges, Sledges etc.
Hammer, Pick, German & Machinery Steel
Iron & Steel Forgings of all descriptions
General Blacksmithing.

· Telephone Main 5197 ·

SPECIALTY

HAMMERED STEEL SHOES AND DIES, CAM SHAFTS, CRUSHER PLATES, WELL BORING TOOLS, ETC., ETC.

T.P. G.W.P. J.P. E.P.
PENNINGTON
TRADE MARK
SAN FRANCISCO, CAL.

MAIN WORKS:
S. W. COR. MONTGOMERY AND CHESTNUT STS.
SAN FRANCISCO, CAL.

ENGINEERS FOUNDERS MACHINISTS
MACHINERY MERCHANTS

BAKER IRON WORKS

MANUFACTURERS OF

MINING AND MILLING MACHINERY
OIL WELL TOOLS AND SUPPLIES
HEAVY FORGINGS, TANK, STILL AND BOILER WORK
STRUCTURAL IRON AND STEEL CONTRACTORS
LARGEST STOCK OF MACHINERY IN THE SOUTHWEST

WORKS: 932 TO 992 BUENA VISTA ST.
STORE: 220, 222, 224 EAST SECOND ST.
TELEPHONE PRIVATE EXCHANGE 124

LOS ANGELES CALIFORNIA

A. ANDERSON L. T. BROWER W. LEISHMAN

MECHANICS' FOUNDRY

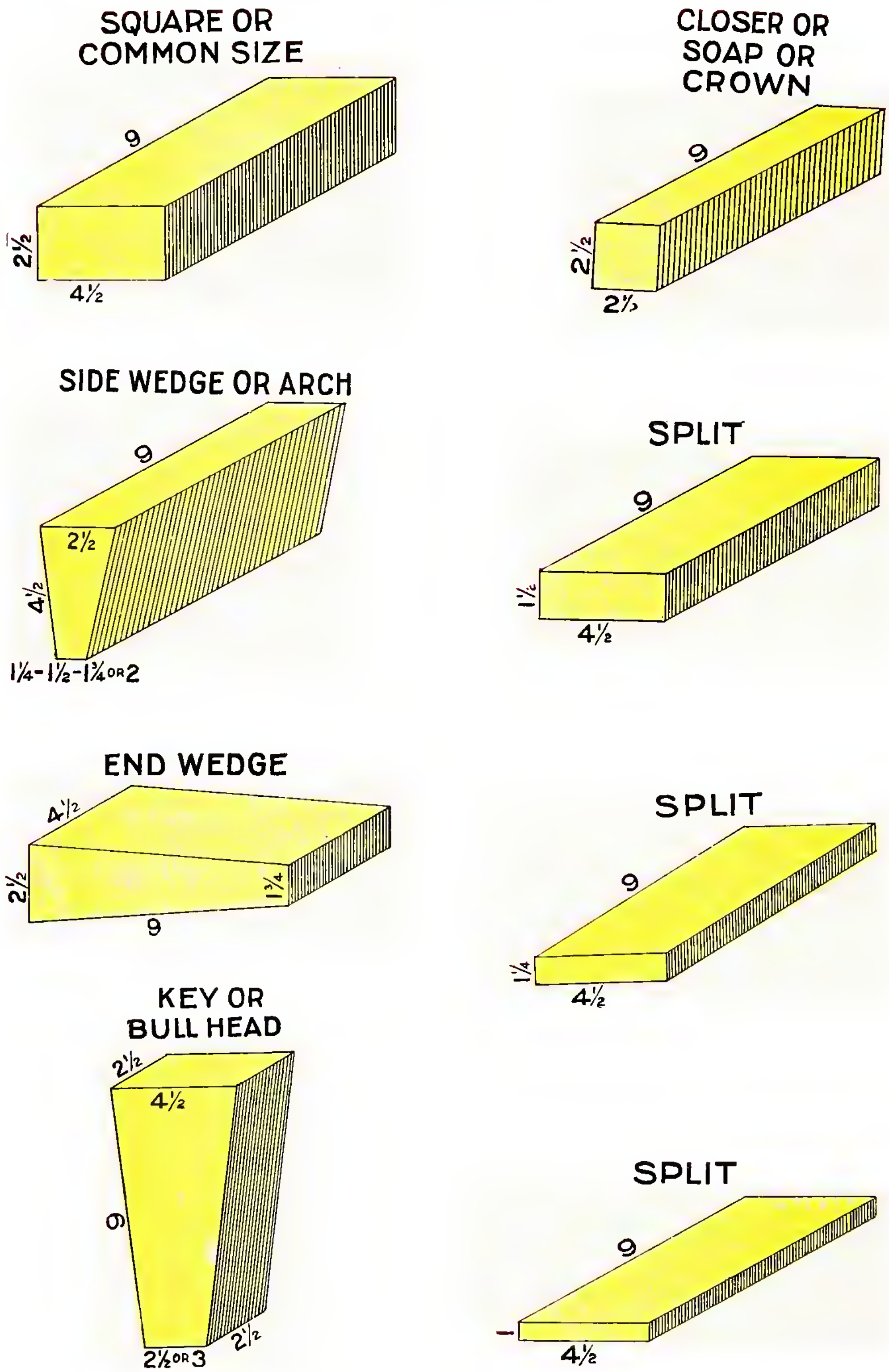
MANUFACTURERS OF EVERY DESCRIPTION OF

CASTINGS

ESTIMATES CHEERFULLY GIVEN
ALL ORDERS PROMPTLY ATTENDED TO

213 FIRST STREET SAN FRANCISCO, CAL.

ENGLISH AND SCOTCH FIRE BRICK

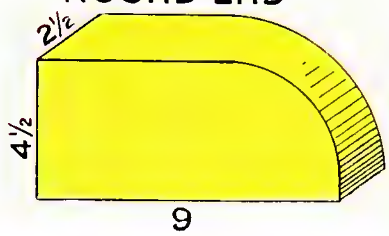


Fresh Snowballs always on hand—The kind that do not melt

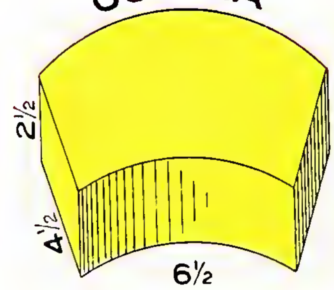
S. R. CHURCH, 307 Sansome Street, San Francisco

ENGLISH AND SCOTCH FIRE BRICK

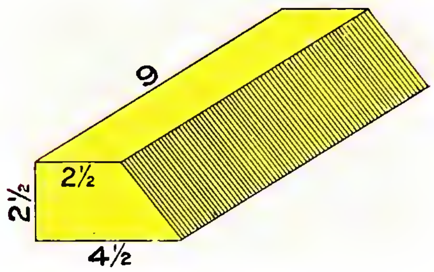
JAMB OR ROUND END



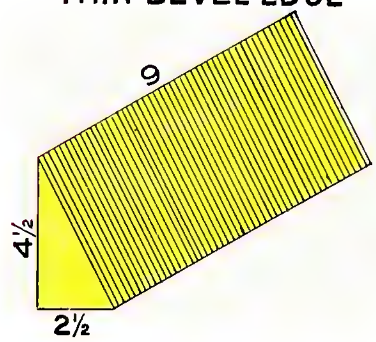
CUPOLA



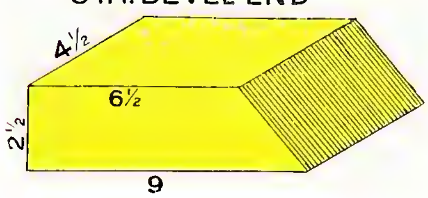
THICK BEVEL EDGE



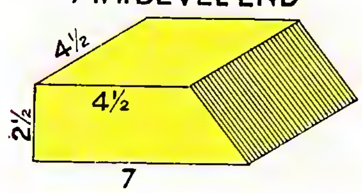
THIN BEVEL EDGE



9 IN. BEVEL END



7 IN. BEVEL END



Uses of Fire Bricks of Different Patterns

Side Wedges or **Side Arches** are used for small arches 4½ inches thick.
End Wedges or **End Arches** are for large arches 9 inches thick.
Bull Heads are used for lining circular furnaces, and are laid horizontally.
Splits and **Closers** are used for making joints, and save labor in cutting squares.
Bevel Sides and **Bevel Ends** are for spring arches.
Cupola Bricks are used for lining cupola furnaces.
Tiles are used for large bake ovens, covering flues, etc., in connection with cement works or boiler seating.

Fresh Snowballs always on hand—The kind that do not melt

S. R. CHURCH, 307 Sansome Street, San Francisco

TABLE OF CONTENTS THIRD EDITION

THOS. D. WEST'S

METALLURGY OF CAST IRON

The third edition has been practically rewritten and contains the author's experiments and researches for the past three years accompanied by much other new matter. Fully illustrated. Price $3.00. Sent postpaid on receipt of price by the Cleveland Printing and Publishing Company, Cleveland, Ohio.

PART FIRST

Operations of Blast Furnaces in Making Cast Iron

PART SECOND

Elements in Cast Iron. Utility of Analyses, Different Mixtures of Iron Used in Making Gray and Chilled Castings

PART THIRD

Properties of and Methods for Testing Fluid and Solid Iron

PRINTERS
STATIONERS
BOOK BINDERS
LITHOGRAPHERS
ENGRAVERS

We do not sell Pig Iron
but we do sell

Pig Skin Bags

as well as a Fine Line of Dress
Suit Cases, Valises, Hand Bags
and other Fine Leather Goods

H. S. CROCKER COMPANY

215-219 BUSH ST. and 227-229 POST ST., SAN FRANCISCO, CAL.

WESTERN FOUNDRY

MORTON & HEDLEY, Proprietors

No. 215 HARRISON STREET

BETWEEN MAIN AND BEALE

SAN FRANCISCO, CALIFORNIA

Castings of Every Description Made to Order

FOUNDRYMEN wanting to make strong and clean castings should use the best quality of

COKE

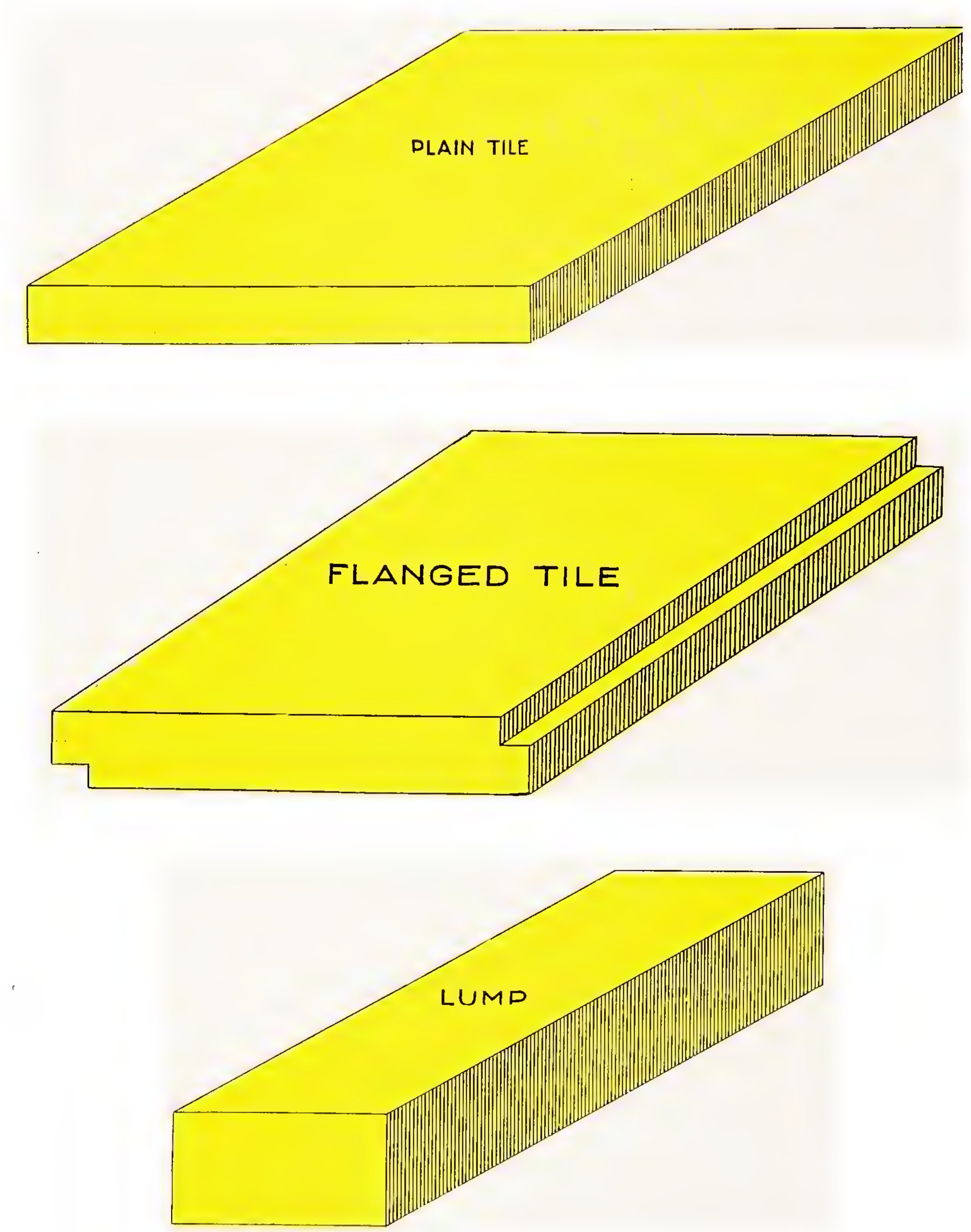
Coke that will produce the best castings always on hand and for sale in lots to suit. Orders solicited

S. R. CHURCH
307 Sansome Street
San Francisco

FRESH SNOWBALLS ALWAYS ON HAND
THE KIND THAT DO NOT MELT
ALSO ALL OTHER BRANDS OF IMPORTED FIRE BRICKS

UNITED STATES CRUISER "OLYMPIA," DEWEY'S FLAGSHIP, BUILT BY THE UNION IRON WORKS, SAN FRANCISCO

ENGLISH FIRE TILES



Fresh Snowballs always on hand—The kind that do not melt

S. R. CHURCH, 307 Sansome Street, San Francisco

English Fire Tiles

S. R. CHURCH

307 Sansome Street, San Francisco

The following are the sizes which we carry in stock

PLAIN

8 inches x 8 inches x 2 inches
10 " x 10 " x 2 "
12 " x 6 " x 2 "
12 " x 12 " x 2 "
12 " x 15 " x 2 "
12 " x 18 " x 2 "
12 " x 20 " x 2 "
14 " x 6 " x 2 "
14 " x 14 " x 2 "
15 " x 15 " x 2 "
16 " x 6 " x 2 "
16 " x 16 " x 2 "
18 " x 6 " x 2 "
18 " x 18 " x 2 "
24 " x 12 " x 2 "

24 inches x 14 inches x 2 inches
28 " x 12 " x 2 "
28 " x 14 " x 2 "
20 " x 15 " x 3 "
24 " x 12 " x 3 "
24 " x 14 " x 3 "
24 " x 15 " x 3 "
28 " x 12 " x 3 "
30 " x 12 " x 3 "
30 " x 15 " x 3 "
32 " x 15 " x 3 "
36 " x 15 " x 3 "
36 " x 20 " x 3 "
36 " x 21 " x 3 "

FLANGED

20 inches x 12 inches x 3 inches
24 " x 12 " x 3 "
24 " x 15 " x 3 "
28 " x 12 " x 3 "

28 inches x 15 inches x 3 inches
30 " x 15 " x 3 "
36 " x 15 " x 5 "
20 " x 15 " x 4 "

LUMPS or BLOCKS

20 inches x 6 inches x 6 inches   18 inches x 6 inches x 5 inches   15 inches x 6 inches x 5 inches

Any sizes of Tiles not mentioned in the above list can be made to order.

Fresh Snowballs always on hand—The kind that do not melt

New York London Lima Callao Valparaiso Santiago Concepcion

W. R. GRACE & CO.

234 CALIFORNIA STREET
SAN FRANCISCO

IMPORTERS OF

PORTLAND CEMENT

LEADING BRANDS
"JOSSON" AND "FEDERAL"

—AND—

GERMAN SYNDICATE COKE

VULCAN ICE MAKING AND REFRIGERATING MACHINES

Of any desired Capacity, on the Simplest and most Economical System

REFERENCE: 300 MACHINES IN OPERATION

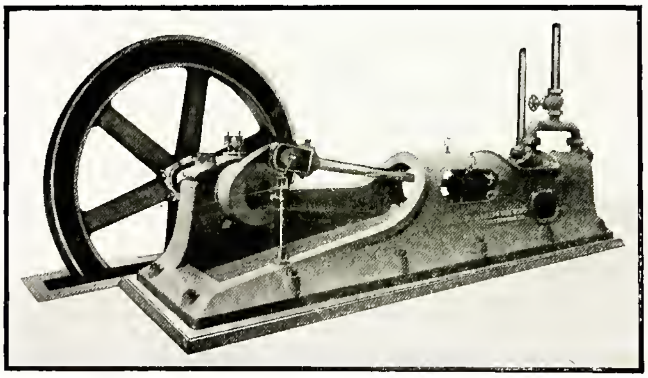
We Carry in Stock

AMMONIA PIPING	MINERAL WOOL	CHAPMAN VALVES
AMMONIA FITTINGS	CONDENSING COILS	INSULATING PAPER

SEND FOR CATALOGUE

VULCAN IRON WORKS

505 MISSION STREET SAN FRANCISCO



THE PACIFIC COAST CO.

STEAM AND DOMESTIC COALS
FOUNDRY COKE

BEST IMPORTED AND DOMESTIC GRADES OF GAS COKE

OFFICES AND COAL DEPOTS AT

PORTLAND
ASTORIA

SEATTLE
SAN FRANCISCO

OAKLAND
SKAGUAY

JUNEAU
SITKA